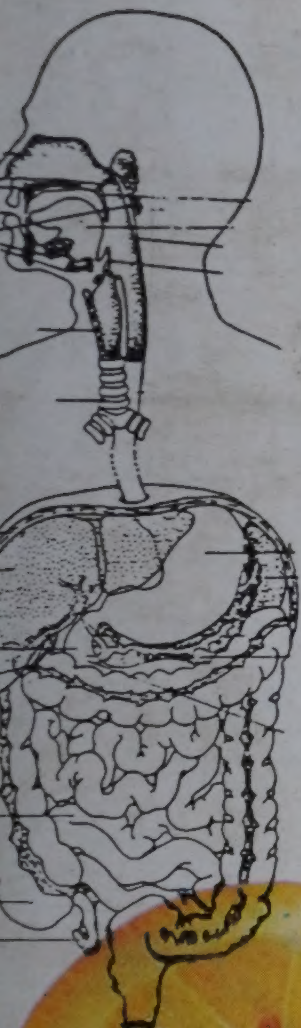
MAJOR ISSUES IN FOOD & NUTRITION SCIENCE

M. LALITHA



A major objective in India's Eighth Five Year Plan has been to bring about an overall improvement in the nutritional status of the population. Since the major dietary problem leading to malnutrition is more of calories in the diet than of protein, the overall strategy is to bridge the calorie gap among various segments of the population. Nutrition and health education has been stepped up through inputs in the school curriculum, training courses of medical and allied health professionals, among others. In this perspective, the present publication brings together a valuable set of papers, articles, essays and notes with a focus on the major issues in food and nutrition science education approaches. The focus extends over food science in developing countries, nutrition and poverty, basics of nutrition and health, various kinds of foods, nutrition for infants and children, and also a comprehensive glossary of nutrition and food storage and preservation. The incidental materials relating to vitamins and balanced diets as well as food habits and exceptional food requirements, will be of particular use as 'instant' reference points. The publication will be of particular use to students and practitioners of food and nutrition science, in the context of the need for balanced human development for long-term national interest. The book will be a welcome addition to the rather meagre contemporary literature on the subject.

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Preface

The pressing need for food and nutrition science education for people of all ages has come to be realised only in relatively recent years. For very long, this vital subject, which concerns a nation's health, well-being and development, particularly its children and young adult population, was understated, underappreciated, and unorganised in most countries of the developing world. It was the rapid progress in the life sciences and the unerring statements in terms of the linkages between nutrition and development of the human being, that awareness grew and nutrition began to appear as an essential component of all welfare and development programmes. The mid-day meal scheme in India for school students and the incidence of malnutrition among expectant mothers in rural areas of the country have placed an additional emphasis on the quality of food and nutrition science education and awareness in the country.

A major objective in India's Eighth Five Year Plan has been to bring about an overall improvement in the nutritional status of the population. Since the major dietary problem leading to malnutrition is more of calories in the diet than of protein, the overall strategy is to bridge the calorie gap among various segments of the population. Nutrition and health education has been stepped up through inputs in the school curriculum, training courses of medical and allied health professionals, among others. In this perspective, the present publication brings together a valuable set of papers, articles, essays and notes with a focus on the major issues in food and nutrition science education approaches. The focus extends over food science in developing countries, nutrition and poverty, basics of nutrition and health, various kinds of foods, nutrition for infants and children, and also a comprehensive glossary of nutrition

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1
Food and Nutrition in Developing Countries

One of the earliest organized efforts to identify and quantify the food and nutrition problems of developing countries was the series of World Food Surveys that were conducted by the Food and Agriculture Organization (FAO) of the United Nations starting in 1946. A little later the United States began to conduct a series of even more comprehensive food surveys in developing countries under the aegis of the Interdepartmental Committee on Nutrition for National Defense (ICNND).

In the following remarks, we will attempt to describe some aspects of the response by aid-donor countries and United Nations to nutritional problems in the less developed countries as they are revealed in these and similar nutrition surveys and investigations; we will further suggest some possible answers to the questions that this response has raised, and we will finally urge that the different distinct and complex food systems that exist in both developing and industrialized communities should be investigated by in-depth social anthropological studies to enhance the chances for successful nutrition intervention.

Aid Donors and Food Needs

The usefulness of these global and national food surveys should not be underestimated, despite the inherent risks in making generalizations from such vast and complex undertakings that deal with large and disparate populations, each with a variety of food habits. They provided, by and large, an adequate clinical

picture of the spectrum of foods consumed by the people studied. The ICNND studies in particular do not seem to have suffered from cultural bias; the overwhelming majority of the team members were host-country nationals, and all foods and beverages—including snack foods—were included in their surveys. It is safe to say that the FAO surveys provided a much needed baseline for nutrition policies and nutrition planning programmes of both the United Nations and individual countries, and the ICNND surveys provided valuable detailed statistics and data on specific nutrients, foods, food habits, nutritional status, and some indication of the steps needed to attack specific regional malnutrition problems.

Once the problems were identified, however, the response of the aid-donor countries and the U.N. agencies was generally culturally biased. The conventional approach to the food problems of developing countries was, and still largely is, seen through Western eyes, and as a consequence Western technology has had a serious influence upon these countries in at least three ways: one is in the kinds of foods distributed in emergency situations and for long-term food aid; the second is the way in which educational institutions determine the outlook of the food scientist or technologist who works on problems typical of developing countries; and finally there is the effect that the export of the Western model of agriculture and other food production techniques has had on food production.

Export of food products: Aside from food grains, the United States and other industrialized countries distribute products of Western food technology such as dried skim milk (DSM), corn-soy-milk (CSM) mixtures, wheat-soy blends (WSB), and Incaparina. These products are wholesome and nutritious, and if consumed as intended will provide the valuable high-quality protein required by the target populations for adequate growth, development, and maintenance. Nevertheless, they are not part of the traditional diets, and in the case of DSM, CSM, and WSB, which are distributed free, there are numerous tales of misuse and non-use that can be documented. The donor agencies tend to evaluate the effectiveness of such products in their reports by assuming that the children for whom they are intended actually receive and consume the intended daily ration. However, in many cases, even when the products are provided to children in controlled school feeding programmes, actual measurements indicate that about 50 per cent of the food is wasted.

Incaparina is an example of a nutritious food product created for production and use in a low-income market. The result of a prodigious development effort by INCAP (Instituto de Nutricion de Centro America y Panama) to use locally available materials for the manufacture of a nutritious food, it has been on the market in Central America for 15 years. Nevertheless, it cannot by any means be considered to be a success in any conventional sense of the word; it does not reach a significant portion of the population for which it was designed, its manufacture is not profitable, and its beneficial impact on the national nutritional status is not noticeable.

Export of food technology: The second way in which Western influence is felt is in the export of technology in the education and training of food scientists and technologists. The products of American curricula are, on the whole, oriented toward problems of food processing, packaging, and distribution methods developed and used in the industrialized countries—with all that this implies in terms of access to raw materials, manufacturing technology, and chemical processing industries, and the vast infrastructure necessary to support all these activities. In a recent discussion of this problem, George F. Stewart stated: "Few if any of the food science and technology curricula in industrialized nations are training students for the real jobs that exist in developing countries." In terms of those graduates from the industrialized nations—or those from less developed countries—who remain in the United States after graduation, there is simply the tendency to perpetuate Western approaches to Western food problems. To the extent that this represents a problem, it is of our own making. But in terms of the graduates who move on to international agencies or go—or return—to the less developed countries, we are creating for those countries a problem not of their making; we are supplying them with scientists and technologists to work directly on serious problems, and with professors who set up departments of food science and technology, yet all are grounded in curricula set up originally to meet our own needs.

In a recent publication of the National Academy of Sciences (NAS), a leading food scientist from a developing country put the problem this way: "... a great portion of what food is produced [in developing countries] goes to waste on the farm, in the markets, and in the home. Proper food storage, processing, and packaging

could make much more food available and encourage farmers to produce more. Yet, few workers in developing countries have been trained in these aspects of food science. Education and training in food science, as in other fields of science and engineering, suffer from the developed-country orientation of curricula designed and followed in institutions of higher education in both developed and developing countries. Most food scientists are trained for jobs that are unsuited to the developing country's needs and for which no funds are available. Scientists, nutritionists, and allied workers could contribute much more to their country's development now and in the future if their training were reoriented toward the problems that abound in their villages and towns."

Export of agricultural technology: The third way in which Western technology has affected the food situation in developing countries is in the export of Western agricultural technology. To say that the adoption of "modern" agricultural techniques by the food-deficit countries has been a mixed blessing is no longer as heretical as it was a few years ago. The Green Revolution, with its switch to crops amenable to mechanized farming and requiring irrigation and intense fertilization, has been viewed with considerable skepticism for some time because of its substitution of capital for labour and the consequent effect of increasing the economic gap between the wealthy farmer and the labourer in some situations. But other unforeseen—or ignored—aspects of monocropping are beginning to raise questions in the minds of some. Aside from the genetic vulnerability of such crops to attacks by insects and disease micro-organisms, the effect on food quality has perhaps not been all that beneficial. For example: "Certain food plants are maladapted to monoculture whereas in traditional intercropping systems they become not only more productive, but they also encourage the growth of other food plants. Thus, the cereal stalk of sorghum or millet may provide a convenient support for climbing legumes and these return nitrogen to the soil. The clump of growing vegetation may provide sufficient shade to allow green leafy vegetables or fleshy fruits and vegetables to survive. Organizing these crops into an orderly rotated farming system would inevitably result in the loss of shade and possibly the vegetable crop. Such a situation arose during the initial experiments in applied nutrition at Hyderabad in India, in the early 1960's. Attempts to show local inhabitants the advantage of producing lettuce and cabbage by

methods used in temperate climates were disastrous, since survival of the vegetables in the hot and arid Deccan [plain] could only be achieved by applying much water, a precious commodity at the best of times."

The Western "mass cultivation" approach to agriculture has another consequence which is perhaps more serious. One normally associates dietary variety with the affluent industrialized nations and restricted dietary choices with developing countries. However, in actuality the number and variety of indigenous foods traditionally eaten in less developed countries is quite large, while the apparent large variety of food available in affluent societies "represent(s) permutations and combinations of a very limited number of food resources". This tendency to decrease the number of different food resources consumed may have serious long-term effects with respect to toxicants naturally occurring in foods. Even in this age of food additives, more than 99 per cent of our daily diet consists of the naturally occurring chemical components of the foods we consume, and among these is a variety of naturally occurring substances which may be, or have been shown to be, toxic under certain circumstances. This is not to say they necessarily constitute a hazard, because the potential toxicity may not give rise to any injury; rather, the toxicity may depend on the circumstances, such as conditions of food preparation, quantity ingested, or antagonistic interactions with other food components. It is the two last-named conditions that become important in evaluating the wisdom of limiting the variety of foods in a diet, and illustrate what has been called the "concept of the *safety in numbers* as applied to the chemical components of the diet". Thus, not only are the chances lowered that a particular naturally occurring toxicant will be consumed to a hazardous degree, but the chances are raised that the multitudinous antagonistic reactions possible among such substances will act as a protective device if the diet contains the widest possible variety of foods.

Study of Food Systems

In a lecture entitled "Food as an art form", given to the Royal Anthropological Institute of London in May 1974, Professor Mary Douglas raised a number of considerations that are, or should be, of crucial importance to nutrition planners. In the absence of adequate answers to many of the questions that Professor Douglas asked, it appears to us that food and nutrition planning, and the

development and large-scale acceptance and use of new foods and food supplements, will remain largely a matter of chance, especially in developing countries with their frequently conservative and unique food consumption patterns.

Professor Douglas points out that since food is consumed partly because of the biological function it serves, and partly because it also has a very clear esthetic function, it is similar in many ways to clothing, architecture, and utensil design. To understand properly the way in which food is viewed, manufactured, and utilized in different societies, it must be considered just like the other necessities of life just mentioned. Food is a system that is made up of a series of temporal, spatial, and sensory events combined according to certain rules. These rules are practically always unwritten but they are nonetheless precise, rigorous, and well-known within a particular society. Knowledge of the rules that govern a particular food system is essential if it is desired to make changes in the system. It is, for instance, vital to know how eclectic a particular system is in regard to the range of materials and ingredients it tolerates. Are there some parts, Professor Douglas asks, that are very stable and others that are more of the United States or other industrialized communities? Some people in U.S., Canadian, and European universities have begun to be concerned about efforts to introduce a dietary change should be directed.

A similar question addresses the degree of freedom characteristic of one kind of food in one or another type of setting. How much is the preparation of the food made visible, how much is kept offstage? How important are the sensory qualities of foods belonging to the system under investigation? How important is it that a particular food be hard or soft, gritty or smoothly textured? Where and when and how do the sensory qualities of the particular type of food outweigh its real or imagined nutritional qualities? What odors, tastes, and colours are permitted, and in what types of food for what occasion? Another point of investigation of considerable importance to the nutritionist engaged in food relief to a community is the effect of pressures of the social, economic, and religious systems upon the food system. Do these pressures enhance or diminish flexibility, and are there differences in the effects that a stagnating or a rapidly changing social system has upon a food consumption pattern?

These and many more such questions relating to the rules according to which foods are prepared, sold, and consumed in a society are very rarely asked, and they are certainly difficult to answer. We suggest here, however, that correct responses promise to increase significantly the chance for a successful nutrition intervention.

Possible Solutions

There are several ways in which Western technology can be made more useful in helping the food-deficit nations solve their food problems. One thing which seems obvious is that some serious rethinking must be done about the objective of our food science and technology education, primarily in terms of its usefulness when faced with conditions and food problems completely foreign to Western experience. We have rendered a disservice to food scientists from—and in—developing countries when, as a result of their education, they tend to concern themselves with the types of packaging, preservation, flavouring, colouring, texture, "mouth-feel" problems associated with the processed convenience foods information while getting started on the research suggested ... or during the course of the investigation.

There are courses of study now which are beginning to take these problems into account. Some examples of the schools involved in this way are: Iowa State University, Purdue University, University of Rhode Island, University of Florida, University of Manitoba, Northern Alberta Institute of Technology, and the Agricultural University at Wageningen.

Some steps are also being taken in developing countries to reorient the education of food scientists and technologists. The University of Ghana and the University of Ife are two examples, but one of the major efforts is being made at the International Food Technology Training Centre in Mysore, India. This institute was established in 1964 with FAO assistance, at the Central Food Technology Research Institute (CFTRI) (which has long been working in food research and which has achieved some notable successes in applying modern food science and technology to local conditions in South and Southeast Asia), and offers both a master's degree in science and a programme for continuing professional education.

Another approach to directing the attention of students,

professors, and government and industrial laboratory scientists—in both the industrialized and non-industrialized nations—to specific problems of developing countries has been taken by the NAS. Through its Advisory Committee on Technology Innovation the NAS has published *Food Science in Developing Countries : A Selection of Unsolved Problems*, a compendium of problems in food science and nutrition selected primarily by scientists and other workers in the less developed countries as topics worth immediate examination. Thus, the publication represents a view of priorities which is "theirs" and not necessarily "ours," and is intended to stimulate the interest of research workers and technologists in solving these and similar problems. The problems are presented in a uniform format (problem description, background information, possible approaches to a solution, special requirements, bibliography), and each problem concludes with the name of one or more "key contacts" who have agreed to act "as personal contacts to whom the interested reader may turn for advice and experimental? It is clear that a precise answer to these questions would have an important bearing on the nutritionist's decision as to where in the system will help illustrate what we have been talking about in this discussion. The first concerns the use of oilseed cake from traditional oil-extraction processes. In Ghana, for example, the traditional method for vegetable oil production is water extraction, but this removes only about 30 per cent of the oil present in the seed. Because of its high oil content the residue is unsuitable for use as animal feed and is difficult to process further by local methods, for use as human food. The tragedy in this situation is that oilseed cakes are excellent sources of protein and calories for supplementing deficient diets. The article points out: "Because small, traditional processors are widely scattered, any attempt to gather press-cake for further processing takes so long that both oil and protein residues deteriorate, which discourages further processing. Since the small-scale, traditional method of vegetable-oil production cannot yet be discontinued, any method that improves the efficiency of the water-extraction process will strengthen the vegetable-oil industry of countries like Ghana. If the traditional process could be modified to stabilize the residues, protein-short countries could use valuable oilseed protein in foods". Some possible approaches are suggested, a bibliography is given, and two key contacts are listed, one in Ghana (the

contributor) and one in the United States.

The second example is a problem entitled "Milling quinua seeds". The contributor of this problem begins by discussing the need for protein, especially with young children, and the unavailability of milk for a variety of reasons, to large populations. He then reminds us of the existence of quinua *(Chenopodium quinoa)*, a little-known plant which has a long history of use in human foods in Latin America, particularly Peru. This plant produces a grain with a high protein content, but even in its country of origin (Peru) its use is hampered because traditional methods of processing do not uniformly remove the undesirable flavour characteristics of some of its constituents (saponins). The discussion goes on to point out that those constituents seem to be present in the outer layer of the seed but, because of the shape of the seed, conventional milling techniques do not always remove them. The possible solutions suggested involve three approaches: *(i)* develop new milling techniques or equipment; *(ii)* experiment with altering the flavour components of the seed by varying cultivation techniques combined with genetic selection to increase grain size, alter the seed shape, and/or reduce the saponin content, and *(iii)* concentrate on the removal of saponin by improvement of the traditional extraction techniques. Again, a bibliography is given; the key contact listed, in this case the contributor, is in Peru.

These two problems illustrate two of the points outlined at the beginning of the previous section. The first is the value, or rather the necessity, of using the best of Western technology to improve upon, rather than displace, traditional food processing techniques. Where this is possible, it is certainly more desirable, in terms of rapid acceptability, use of local skills, materials and equipment, and low cost, than beginning with the assumption that the traditional processes are primitive, useless, outmoded, and should be replaced—with all the implications of this approach in terms of new, "modern" equipment and the foreign exchange needed to purchase it. The second point illustrated is the wisdom of examining the culture to see what traditional crops exist whose nutritional impact on the diet might be enhanced with the input of some modern technology—rather than deliberately displacing such crops with others more amenable to mechanical mass cultivation.

Finally, a third example from the NAS publication serves to

illustrate a third point, namely, that Western technology can be usefully applied to problems in developing countries by selecting the techniques best suited to improving a traditional food. In indigenous sources of enzymes for more rapid fermentation of fish, the problem of the time required for traditional processing is discussed. In these processes, where the endogenous enzymes of fish produce the traditional fermented fish pastes and fish sauces ubiquitous throughout Asia, sometimes 8 to 10 months are required for the fermentation to be completed. The contributors of this problem suggest that by applying modern enzyme technology, it might be possible to use other known proteolytic enzymes of plant or fungal origin to accelerate the traditional process without disturbing traditional flavours and textures. Four key contacts are listed, two of them being in Asia and two in the United States.

Summary and Conclusions

It is particularly important for us not to lose sight of the fact that people have been around for a long time and that they achieved remarkable technical skills long before Western science was developed. An anonymous writer from the Food and Agriculture Organization has observed: "It is a commonplace that the fundamental discoveries which made civilization possible—fire-making, tool-making, agriculture, building, calculating, writing, money—were all apparently made outside the area which has given us the marvels of modern science." The writer might well have added that it is commonly overlooked that food technology was not suddenly developed in the 20th century but has been very much a part of the lives of people everywhere ever since they began doing more to their food than gathering it and eating it raw. Lamb's "Essay on Roast Pig" may not be an accurate account of the first conjunction of fire and food, but cooking is a rather ancient practice. Fermentation is another complicated processing technology which is a traditional part of most cultures, particularly those in warm climates—beer, yogurt, cheese, the fish pastes and sauces of Asia, the palm wine of Africa, and soy sauce, are but some examples. Native Americans, besides accomplishing marvels in plant genetics and crop development, also developed water extraction methods for treating acrons to render the flour palatable and edible, and the alkali method of processing maize. Furthermore, the developed a cure for scurvy—by making a water extraction

of pine needles which are rich in ascorbic acid—long before it was first reported by Jacques Cartier in the 16th century. Similarly, calcium-deficient diets of pregnant and nursing women were traditionally successfully supplemented by calcium-rich powdered deer antlers in northern China. Among the Chinese and Greeks, goiter was cured by eating certain kinds of seaweed centuries before the disease was traced to a lack of iodine, and Kenyans learned to such salt-rich earth to avoid salt depletion symptoms after arduous exertion in tropical heat long before "modern science" learned why.

The enumeration of examples could go on, but this was not meant to be an essay in folklore. The point is that all so-called primitive societies developed technologies, techniques, and a store of practical knowledge of a wide range of sophistication, by what must be admitted to be the scientific method, and neither their accomplishments and skills nor those of societies "en voie de development" should be ignored or discounted.

We are confident that modern food science and technology has much to contribute to helping the food-deficit nations eat adequately. First, we must find a way of using the best of Western technology without losing sight of the reality of the situation in the third world and without failing to take into account, better than we have done so far, the secondary and tertiary implications of the changes suggested. Second, we must encourage the examination of local problems in terms of the use and improvement of local technologies which are often quite sophisticated and the result of centuries of development. And third, we must inject a greater component of cultural awareness in the education of students to make them more creative in their application of scientific knowledge to local problems and more adaptable to the conditions that exist in developing countries. We should not lose sight of the fact that because of the precarious nature of their food supply, very often developing countries have much more rigid rules governing the production, preparation, and consumption of food than usually is the case in food-surplus societies, and disturbing these rules is a very serious matter. The time is past when "West is best" can be taken for granted; "adapt and adopt" is surely less offensively arrogant and much more to the point.

2
Nutrition and Human Body

Nutrition and national development can be said to be the two sides of the same coin since without adequate nutrition, the development of the human resources of a country cannot be at its best. The varying degrees of malnutrition among children and women determine the morbidity and mortality rates like infant mortality rate, mortality under-5 years, maternal mortality rate, crude death rate and life expectancy at birth, the indicators which reflect the development of a country. Thus, nutrition emerges as one of the most important pre-requisites for national development.

The most vulnerable among the people are women and children. Various achievements in other sectors like agricultural production, food sufficiency and industrial capabilities do not seem to have linked these vulnerable groups with durable bridges to cross gaping valleys of poverty, ignorance and misinformation. Although there has been a significant decline in the prevalence of severe malnutrition, chronic malnutrition and micronutrient deficiencies continue to afflict a vast majority of these vulnerable segments of the population.

The prevalence of malnutrition in Indian children indicates that the critical period for a child is 0-2 years since the level of malnutrition quadruples during the period 0-6 months to 12-23 months. These first two years are precisely the period of greatest physical, intellectual and psychological development of the child. Lack of awareness about correct feeding practices, nutritional needs of infants and young children and how to convert the family

food into complementary food are some of the important factors contributing to widespread malnutrition in the country. Right "care" of children during this crucial period will both prevent malnutrition among children as well as help achieve their full potential for growth and development.

"Child Caring Practices" has, therefore, been decided as the theme of the 15th National Nutrition Week to be celebrated from 1-7th September, 1996, as it would enable focussed attention on critical areas like feeding practices for infants and young children, preparation of complementary foods from the family pot, health seeking behaviour and care of sick children, hygiene practices and psycho-social stimulation. Sound child caring practices in these areas are critical in determining the children's nutritional status as well as their social, emotional and cognitive development.

The critical area for promoting child nutrition and development, therefore, emerges as Information, Education and Communication since adoption of sound child caring practices would depend upon reaching basic information to the masses. Awareness generation on the importance of breast-feeding, introduction of complementary feeding at the right age, nutritional needs of infants, pre-school children, adolescent girls, pregnant and lactating women, knowledge about locally available nutritious foods, common nutritional deficiency diseases, scientific methods of food preparation, care during illness, preparation of low cost infant foods from the family pot would help inculcate sound feeding practices for children. Awareness on the importance of immunisation, safe drinking water, environmental sanitation etc., would help reduce childhood infections besides improving immunisation coverage and utilisation of health care facilities. The role of media, literature and the traditional forms of communication cannot be over-emphasised in this information dissemination process.

The Integrated Child Development Services aim at holistic development of young children by providing a package of services that includes supplementary nutrition, pre-school education, immunisation, health checkup, referral services and nutrition and health education. The Integrated Child Development Services Scheme which started in 1975-76 in just 33 blocks in the country, has now been universalised covering all the 5291 community development blocks and 310 major urban slums.

The celebration of National Nutrition Week in the country during 1-7th September every year aims at creating nutritional awareness among the people. The Food and Nutrition Board of the Department through its regional and field offices in various States co-ordinates special programmes during the week enlisting the co-operation of various organisations including State Governments, universities, home-science colleges, NGOs etc.

This year's theme "Child Caring Practices" is timely and calls for a concerted nation-wide effort to strengthen these practices for preventing malnutrition and promoting child development. It is time to seriously review our efforts in this area and redirect our initiatives towards a more comprehensive approach to strengthening child caring practices. The new model of development is to grow on a wide base of support from the family, community, Government, NGOs and the Media to empower women to make informed decisions on food, nutrition and feeding practices to make the society healthy and strong, and the people a strong human resource for a vibrant economy.

Nutrition and Development

The importance of nutrition is amply brought out in the title "Food becomes you" by Dr. Ruth Leverton. We should perhaps add, "If you eat the wrong foods, you become the wrong `you'. As Bertrand Russell observes, the absence of iodine in the diet can turn a genius into an idiot. Although fortunately such conversions have not been attempted, it is possible that many potential geniuses do not reach their full stature because of poor nutrition which affects not only the life of an individual but of those around him. When malnutrition is widespread in a community, the whole community acquires characteristics such as lethargy and inertia and these become more or less a tradition. The drive to improve the home and environment found in the west is not found in poor countries. Even to a casual observer, western society appears to be different from our society. These differences are found in little things such as the pace with which men and women walk and the vigour with which children play. In the west, a substantial part of a man's leisure time is spent in gardening, carpentry, making additions to the home, building a spare cottage in the country, swimming, etc., whereas most of our leisure time is spent in idle gossips or just lazing around. The little patch of land around a western home blooms into a beautiful garden. It seldom does here

without the help of a gardener who also does not do a full day's work. A poor man in this country prefers to go without vegetables rather than cultivate a patch of greens. This is not to say that individuals with drive and initiative are absent in our society but their proportion does seem to be far less. These differences may not entirely be due to nutritional factors and well-nourished individuals in the upper class in this country are certainly not models of productivity. However, most individuals are prevented from making their best efforts if their health is below par.

Physical Stature

As started in chapter 1, the growth of the body as well as adult height depend to a large extent on dietary intake during growth, although heredity also plays a role. In this and other developing countries the effects of undernutrition are dramatically evident when we consider the growth rates of people in the upper classes who have enough to eat and the poor who do not. Both groups come from the same racial stock so that heredity cannot be entirely blamed for the slower growth of the poor. The growth rate of the poor and upper classes in this country, as compared to western norms, are shown in Figs. 2.1 to 2.4. The differences in weights

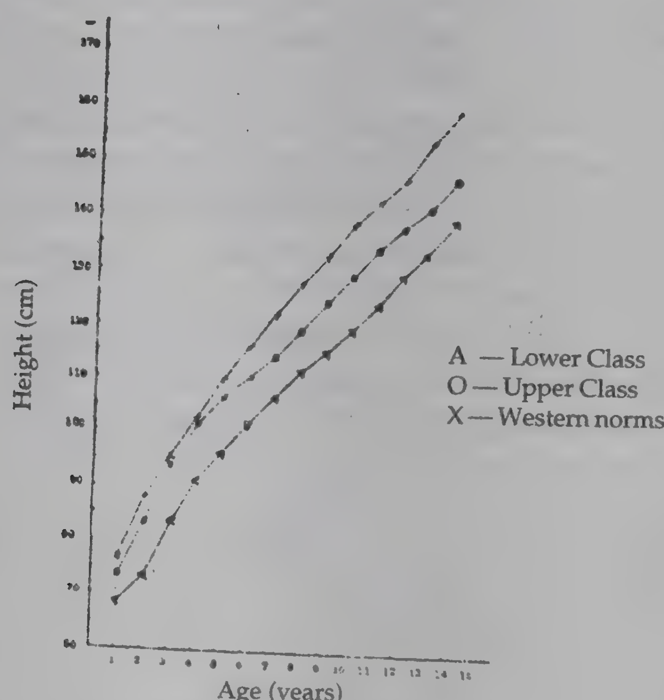

Fig. 2.1 Heights of boys in the lower and upper classes in Gujarat as compared to western norms.

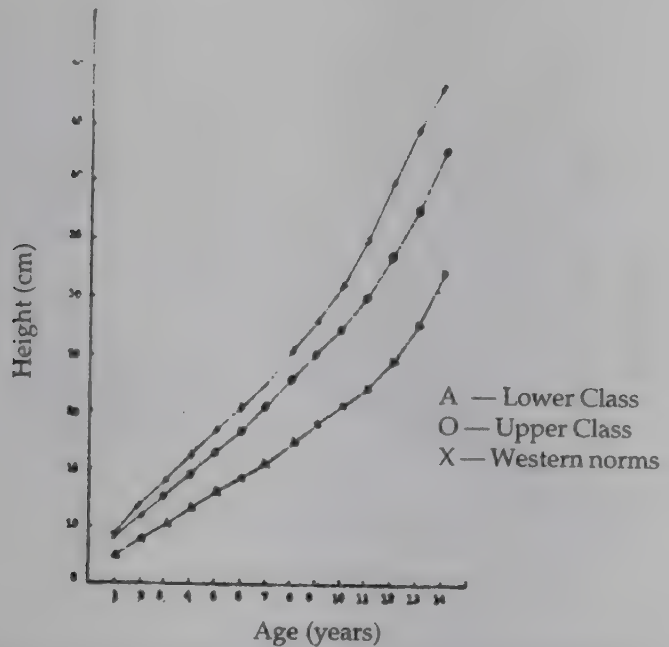

Fig. 2.2 Weights of boys in the lower and upper classes in Gujarat as compared to western norms.

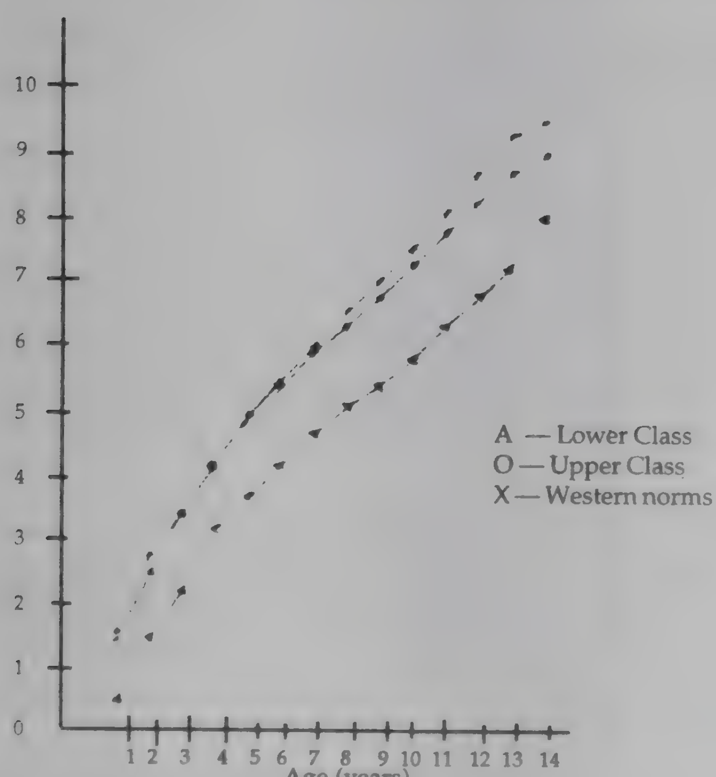

Fig. 2.3 Heights of girls in the lower and upper classes in Gujarat as compared to western norms.

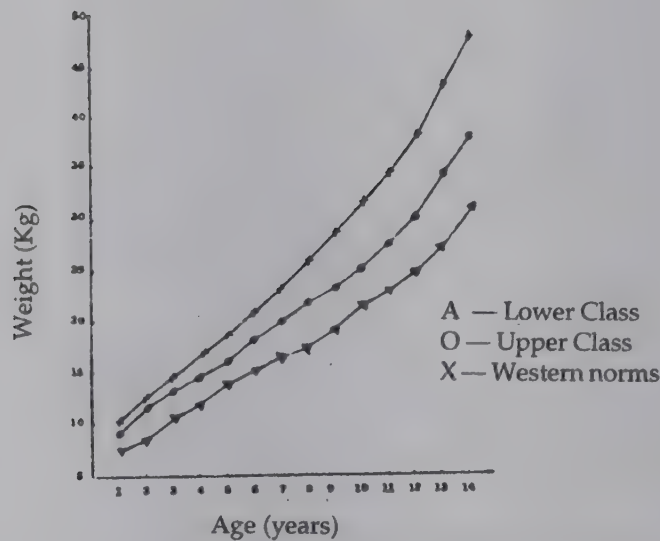

Fig. 2.4 Weights of girls in the lower and upper classes in Gujarat as compared to western norms.

between the three groups is not entirely due to that in heights as can be seen from Figs. 2.5 and 2.6.

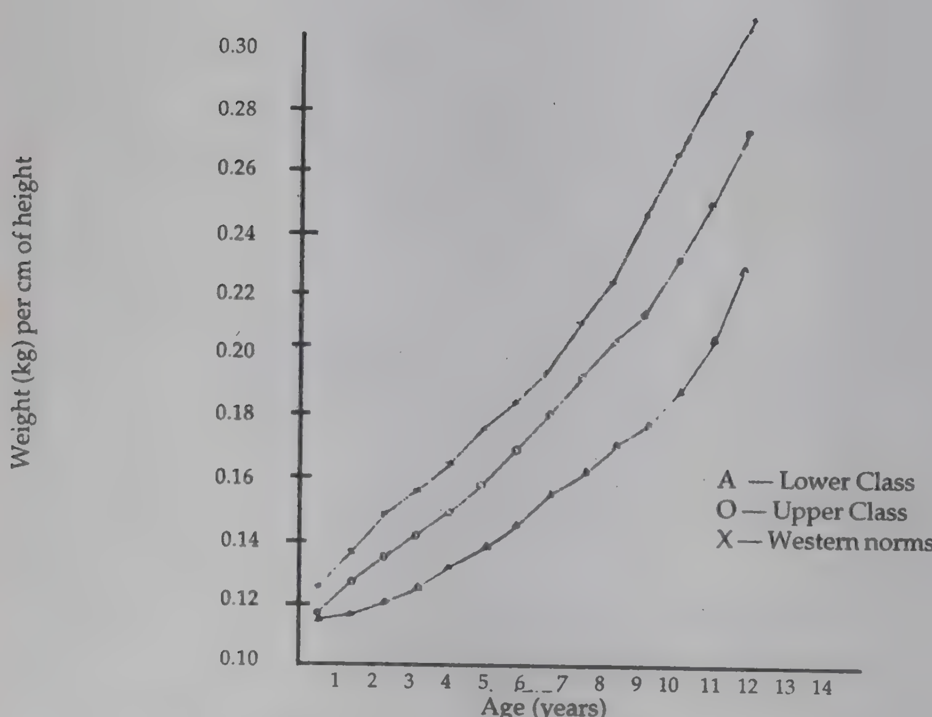

Fig. 2.5 Weight (kg) per unit height (cm) of boys in the lower and upper classes in Gujarat as compared to western norms.

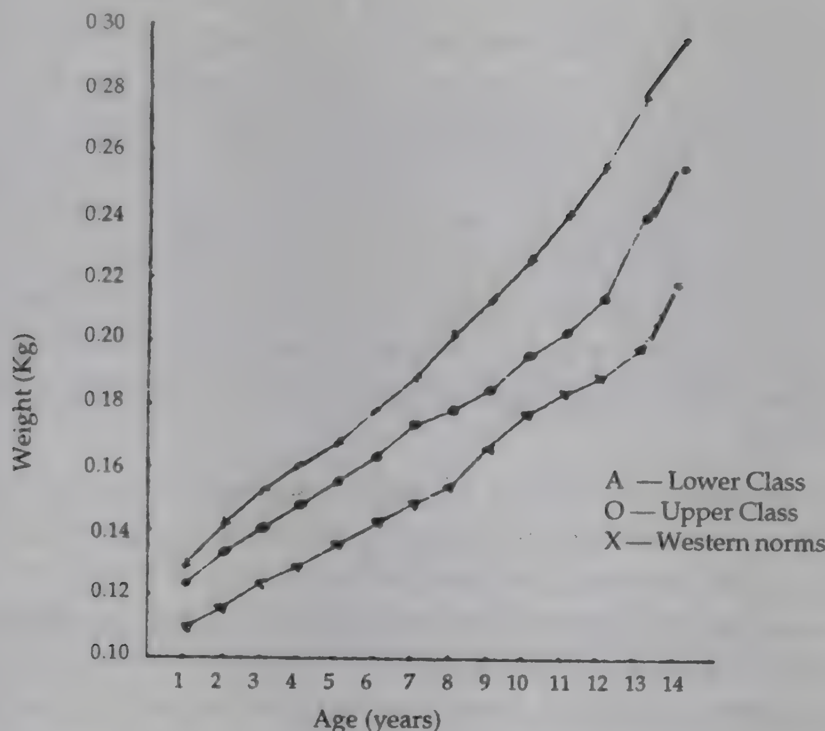

Fig. 2.6 Weight (kg) per unit height (cm) of girls in the lower and upper classes in Gujarat as compared to western norms.

Although height and body build are affected by heredity, the difference in physical stature between the poor and upper class in this society is mainly due to differences in nutrition as not much difference is found till the age of six months or so. Further, when children in the poor group are given food supplements they grow as well as those in the upper class. The children in Japanese parents settled down in the U.S.A., were found to be taller and heavier than their cousins at home. The average birth weight in Japan has gone up with improved nutrition during the last few decades. These changes show the role of diet in determining physical stature.

A person with a good body build is better equipped for heavy manual work, athletics, sports, etc. While a well-nourished individual who is small because of hereditary factors functions quite well, the same may not be true of people who have become stunted because of chronic hunger.

Psychological Status

The effects of malnutrition on psychological characteristics may be even more serious. Very severe malnutrition in early life has been found to affect intellectual development and this is

sometimes reported to be not fully remedied even by a good diet subsequently. Experimental animals undernourished in early life are found to show a number of behavioural changes such as greater emotionality, increase in purposeless activity, decrease in exploratory activity, etc. They also show a tendency to hoard food presumably arising from insecurity about food supplies. In some situations (*e.g.*, severe protein deficiency), learning capacity is also affected. Female rats subjected to malnutrition or undernutrition do not care for their young ones as well as well-nourished animals. Sometimes they show aggressive behaviour instead of maternal behaviour.

An individual who is undernourished has to cut down his activity to a minimum in order to survive. If a man getting only 1500 Calories were to do work costing 2000 Calories continuously, he would waste away. The unfortunate thing is that such an individual becomes permanently attuned to a low level of productivity even when more exertion can mean a higher standard of living.

The child who cries all the time for food because of undernutrition or becomes severely apathetic because of protein deficiency is not likely to develop into the same sort of person as the well-nourished child. Scientists have been hitherto concerned mainly with the effects of nutrition on intellectual development but the diffuse and not so readily observed effects on personality may be even greater.

Even adults who are subjected to semi-starvation for a prolonged period are found to experience feelings in insecurity and anxiety about food supplies long after the same have become quite plentiful.

Mortality and Longevity

Poor nutrition also affects longevity. The mortality rates of young children are very high among the poor and a large number die before the age of five (Table 2.1). Deaths below 5 years of age account for a high proportion of deaths in rural areas. The percentage of such deaths is much lower in urban areas, possibly because of improved sanitation and better medical care. The life expectancy of the average man in this country is only about 50 years as compared to more than 70 years in western countries. In western countries, the percentage of people in the older age

groups is much higher.

Infants born of poorly nourished mothers have a smaller birth weight than those of well-nourished ones. The incidence of premature births and miscarriages is also somewhat more common. Fortunately for us, the effects of maternal malnutrition do not have consequences as serious as we might expect so that most of the children even in the poor class are healthy for the first 4-6 months when they are adequately breast-fed. A high mortality is not only a tragedy but a waste. In man, an individual depends on others till the age of 15-20 years.

Table 2.1

Mortality at Different Ages in the Village of Raipura*

Age (years) at death	*% of total deaths reported*	
	Males (298)	*Females (181)*
Still born	6.7	5.0
0-5	62.0	66.8
5-10	4.7	7.2
10-15	2.0	1.1
15-20	1.3	0.6
20-40	4.7	9.9
40-60	11.7	5.5
60-80	5.4	3.9
80-100	1.3	—

* The figures are based on deaths reported to have occurred in 307 families surveyed in the village of Raipura during ten years preceding the survey. Death rate below 5 years was found to be much lower in urban areas. The figures in parentheses indicate the total number of deaths.

An individual dying before maturity has not had a chance to fulfil his potentialities and contribute to the society which has raised him. An individual dying soon after maturity can only make a smaller contribution, generally speaking although a long life by itself does not signify a rich life. After all, as Laski has pointed out, "Antiquity is not experience."

As has been pointed out earlier, malnutrition is associated with clinical symptoms, changes in the composition of blood and tissues. Many of these changes affect the functioning of the

individual. For instance, a person with chronic ulceration of the tongue and mouth is unable to eat properly. One with eye symptoms is also handicapped. A person with anaemia is not able to work at his best.

Malnutrition and Productivity

The productivity of agricultural and manual labourers is low in communities which are undernourished. This is not surprising as work can be performed by man and animals only at the cost of food energy. If an individual consumes 2000 Calories out of which 1500 are needed for basal metabolism, he can only turn out 500 Calories worth of work. If he consumes 3000 Calories, he can turn out 1500 Calories worth of work. This means that a 50 per cent increase in food supplies can enable him to trible his output. The energy intake of Polish miners is of the order of 5000 Calories as against 3000 Calories in Indian miners. In South America, road building was found to be speeded up when the workers were given a mid-day meal. In Germany, during World War II, production in factories declined when the rations were drastically cut, and rose when they were increased. The productivity of an Indian labourer is reported to be 25-50 per cent of that in affluent countries.

This does not mean, however, that extra calories will be automatically converted to work output. A plate of `halwa consumed by a sedentary individual is not followed by an outburst of activity but rather by the acquisition of some more adipose tissue. However, while an individual can remain idle, even when food is available in plenty, he cannot be expected to work if he is starving.

Thus, productivity is hampered because of undernutrition; and good nutrition is not possible with low productivity as it results in low living standards. Efforts should be made to evaluate the impact of improved nutrition on the productivity of factory workers and agricultural labourers.

In addition to low productivity the malnourished individual is absent more often from work because of sickness. Because of poor education and environment in early life and also perhaps because of poor nutrition, his capacity to learn new techniques and to benefit from modern innovations is also limited. This means that the contribution of the malnourished person to society is

much smaller than it might have been, had he been well-nourished. This means that living standards, in countries where the people are malnourished or poor, are low and this in turn results in poor economic capacity and poor diets. Some idea of the purchasing capacity of the Indian as compared to that of the western man can be seen from Table 2.2. Thus we have a vicious circle of poverty resulting in malnutrition which, in turn, results in more malnutrition.

Table 2.2
Cost of Some Common Articles in India and Western Countries*

Article	*Quantity*	*Cost in India*** *(rupees)*	*Approximate cost in affluent countries**** *(rupees)*
Palmolive soap	1 cake	0.70	0.80
Lifebuoy soap	1 cake	0.70	0.80
Sunlight soap	1 cake	0.60	0.80
Cleansing powder	1 tin	1.75	2.25
Tea	1 kg	5.00	8.00
Wheat flour	1 kg	1.00	1.30
Sugar	1 kg	3.60	1.30
Rice	1 kg	2.12	0.80
Butter	1 kg	11.00	13.00
Income per year per capita		480	15000

* On the basis of price levels in August, 1966. The prices have since more than doubled in India and risen to some extent in the west. Income levels have not changed appreciably.

** U.S. $1 = 7.7 rupees.

*** On the basis of information provided by various embassies in New Delhi.

Malnutrition among the Rich

The poorer classes who are ignorant, illiterate and lack purchasing power have perhaps some excuse for being malnourished. We must not forget that conditions such as obesity, diabetes and heart diseases are more prevalent among the upper classes after middle age and dietary factors and faulty living habits are believed to be partly responsible for these diseases. Diseases such as diabetes showed a lower incidence in England during the war when the intake of fats, sugars, etc., was reduced. The upper

classes would also, therefore, appear to need education on sound nutrition.

Even those who have an awareness of the role of dietary factors in the aetiology of these diseases do not always control their diets which underlines the difficulty in changing food habits. Sound food habits must, therefore, be formed at a very early age.

In conclusion, malnutrition affects not only the health and well-being of the individual but also the status and progress of whole communities and nations. The eradication of nutritional deficiency diseases is crucial for the success of our programmes for national development.

SETTING COMMUNITY NUTRITION STANDARDS

We have seen that poor nutrition is partly or fully responsible for low birth-weights, increased incidence of still-births, high mortality during childhood, stunted physical stature, decreased longevity, increased susceptibility to infection, poor productivity, and perhaps, even poor psychological development. The cost of all this to the individual and society is indeed great. What can we do to arrest and reverse this state of affairs?

Some improvement can be expected when the economic conditions improve but the prospects of this happening in the near future are not very bright. In the meanwhile, it would be tragic to allow more and more children to become so severely malnourished that their potential for development is permanently affected. What can we do about this?

Neonatal Period

It is obvious that as poor nourished mothers produce small babies, good nutrition has to start with the mother. It would be desirable to give poor pregnant women food supplements providing energy, protein, vitamin A, calcium, iron and B-vitamins. But this may not be practicable. A most urgent need is to distribute at least iron supplements to pregnant women as anaemia is a major problem in pregnancy and in young children. They can also be given advice regarding the greater consumption of foods rich in carotene, calcium, etc. A simple advice to all the groups would be to increase the consumption of leafy vegetables and pulses. We could have mother and child welfare centres where such advice is given. Such centres may also give advice in family planning. One

reason for the mother's reluctance to limit her family is her fear of losing the children. If she knows that her children are well looked after and stand high chances of survival, her attitude towards family planning can be expected to change. This has, in fact, been the experience in places where such services have been organized. An example is the rural health centre at Narangwal near Ludhiana in the Punjab where the John Hopkins University has organized such services.

Pre-school Children

The care of pre-school children deserves top priority as this group is the one most likely to be malnourished. The group often suffers not only from malnutrition but also from maternal neglect. In rural areas, most of the poor women work in the fields and they leave the child under the care of an older child, who may be only six or seven years of age and not really competent for the job. This also affects the development of the older child who is deprived of schooling as a result of his or her duties as a baby-sitter. Organization of baby creches where the children can be looked after and fed one or two balanced meals or snacks daily, will contribute greatly to an improved nutritional status. We have organized a baby centre for pre-school children in a selected village and helped the village panchayats in 20 villages in Baroda block to organize similar centres. A simple lunch is provided for children in these villages and is based on cereal or millet 40-50 g, legume 20-25 g, leafy vegetables 30-50 g, and oil 5-10 g. A glass of buttermilk can be given wherever possible. A number of one dish meals such as dhokla, debra, khichri and sambhar-rice can be prepared from the above ingredients as suggested. A supplement or meal based on the above would provide 370 Calories, 12 g of protein, 150 mg of calcium, 2000 μ g of carotene and generous quantities of other critical nutrients.

The actual recipe used should be based on local food habits. For instance, parboiled rice cooked with greengram and served with yellow pumpkin is well-accepted by children in Kerala and dhokla is well-accepted by those in Gujarat. Sambhar-rice is already used in Tamil Nadu. This is based on rice, redgram dal, and vegetables. We find that the substitution of sprouted redgram for dal and leafy vegetables for other vegetables such as brinjal and the addition of lime powder to the tamarind juice added can appreciably improve taste and nutritive value of this preparation

without adding to the cost. These simple changes would increase the amounts provided of calcium, iron, carotene, riboflavin and vitamin C.

Such feeding programmes are found to result in improved weight gain, clearance of deficiency symptoms, restoration of blood and serum constituents to normal levels, better bone development and sometimes improved psychological performance, specially, when these programmes are organized at play centres where children are exposed to toys and games and looked after by a nursery-trained teacher.

The cost of such supplements compares favourably with that of processed foods, the cost of which is increased by at least 100 per cent during the preparation, packaging and distribution of such foods. It has also been our experience that children accept such foods much more readily than foods like high protein biscuits. In one village where the children were allowed to eat as much as they liked of either high protein biscuits or dhokla, they took only 120 Calories worth of biscuits and about 300-400 Calories worth of dhokla.

However, facilities may not always be available for the preparation and distribution of cooked foods. This is particularly the case in tribal areas where the families are scattered over a wide area. An alternative would be to distribute ready to eat foods such as biscuits and breads, which can be prepared on large scale and which have good keeping quality. The use of refined flour in biscuits and breads tends to limit their nutritive value and it would be advisable to use at least half the flour in the form of whole wheat flour in such preparations. These foods should be reinforced with calcium, iron and vitamin A. Alternatively, foods such as sukdi or prepared mixes, which can be easily cooked, can be distributed. In some of our studies we have distributed prepared mixtures of roasted wheat and bengalgram, described earlier. The mixture was given in packets of 30-50 g each and the mother given a week's supply at two packets daily and asked to give a conjee, prepared from the same, in lieu of tea. Supplements of vitamin A, calcium and iron can be added to such mixes. This measure was found to improve the nutritional status of young children in poor urban families in Baroda.

At the end of the study, the mothers were given demonstrations

about how to prepare the conjee ingredients. However, most of the mothers would not be bothered to prepare such a mixture on their own but said they would be glad to buy it at nominal cost. If arrangements can be made for the sale of such mixes, the cost being kept down to that of only the ingredients used, this may make an appreciable impact on the health of young children. Initially, they can be given some samples of the product so that the mothers can see for themselves the response of the child and the acceptability of the product. These ready-to-use food mixes can be prepared in rural areas with simple household equipment (now glorified with the term village level technology). The cost of processing and the other ingredients added can be subsidised by the panchayats or others.

Where supplementary feeding programmes are organized, the question arises as to who is to foot the bill. In some villages, in Baroda block, the panchayats have set apart 5-10 acres of land, the produce of which is either used for the feeding programme or sold and the sale proceeds used for the same.

If the play centre of feeding centre is organized in an area where the landed families live, the landless labourers do not send their children there and *vice-versa*. If it is not possible to persuade both groups to send the children to the same centre, either centres should be organized in both areas or priority should be given to organizing a centre for the landless families.

School Boys

The group next deserving our consideration is that of children of the school going age.

Most villagers send their children to a primary school and the school can, therefore, be used as an effective centre for improving the nutritional status of school children and their families through lunch programmes as well as nutrition education.

The meals or snacks can be based on a combination of cereal + pulse + leafy vegetables, as in the case of pre-school children. If cooking is not possible wholesome and simple or parched grains, snacks such as bengalgram and roasted groundnut can be made up into packets and sold at nominal cost. The boys can also be given oil enriched with vitamin A. The school lunch can serve as a nucleus for a discussion of the various nutrients needed by the body, the effects of deficiencies in the same, the foodstuffs

which can provide these nutrients and the formulation of meals based on the same. The children can be made to record their own heights and weights and observe the clinical symptoms present in the group before the initiation of the programme so that they become more aware of the impact of the same on nutritional status. They can also take turns to help with the preparation and distribution of lunch. They can be encouraged to cultivate in the school garden, the vegetables needed for their lunch. Such an approach was found to be very fruitful in a trial lunch organized by us in a village. This experience can serve as a basis of discussing how their home diets can be improved.

School children are found to form an effective medium through which the parents can be educated. Most boys in rural areas have illiterate parents and what they learn in school carries weight with the parents. In this country the views and preferences of sons count for something with the mothers, particularly in rural areas. In one village, where we attempted nutrition education by holding classes in the school, the mothers were also invited to attend these classes. The impact was found to be greater in families where both children and mothers attended and with only children than with only mothers. Similar experiences have been recorded in Israel.

Other Groups

Other groups such as landless labourers, building construction workers and factory workers are also in need of nutritional improvement. While their protein status is not bad, they are undernourished and their productivity will improve with a food supplement provided on the spot. Most of them are also deficient with regard to vitamin A.

Immediate steps are needed at least to eradicate anaemia in women and vitamin A deficiency in children. Suggestions along the above lines have been made by various bodies including certain committees appointed by the Government of India. Organizations such as the UNICEF, FAO and WHO have also contributed to spreading an awareness of the need for nutritional improvement through their Applied Nutrition Programme. Organizations such as CARE have sought to improve the nutritional status of young children and school boys. But these efforts have hardly touched the fringe of the problem and much more extensive and intensive efforts are needed.

Nutrition Education

Poor economic condition does stand in the way of improved nutrition, but ignorance regarding nutrients needed by the body and cheap foods which can provide them are also partly responsible. For instance, most mothers are not so poor as not to be able to afford an ounce of leafy vegetables to the child daily if they realise that this may make a difference between blindness and normal vision. Similarly, the mothers of many kwashiokor children in Kerala were found to have spent quite a lot of money on the treatment of their children, including the purchasing of medicines, tinned barley and glucose, money which was rather disastrously spent when all that the child needed was a greater share of the foods prepared at home in a form suitable for the child.

Information media such as the radio and the newspapers can help. In many areas such as Tamil Nadu, the farmers' programmes are quite popular and perhaps nutrition education can be attempted along with these. Newspapers can have a regular column on nutrition and perhaps one for answering questions relating to nutrition.

Nutrition education should form an integral part of the science curriculum. It can also be integrated with the organization of the school lunch programme.

At present, whatever nutrition education is given in schools is in the form of isolated bits of information, or more often, mis-information scattered in science textbooks. Most of the recommendations are impossible and out of date. It is necessary to formulate a systematic syllabus which will emphasize the use of easily available and cheap foods for satisfactory nutrition. At present, most science textbooks give the impression that good nutrition is not possible without a generous supply of milk, eggs, oranges and meat. As even the upper classes cannot afford these in adequate quantities, the only possible response is to shrug one's shoulders and dismiss all these as so much theoretical non-sense.

In our attempts at nutrition education in a selected village, we aimed at the education of children with the mothers in the school. We first pointed out the deficiency symptoms they had and explained how they can be prevented and corrected. We showed them how to prepare the foods we recommended and helped them to cultivate vegetables and fruits which can improve their nutritional

status. We gave them cyclostyled notes written up on each topic and objective tests to ascertain how much they had understood after distributing transcripts of the lesson taught. We repeated the instructions if necessary and gave a repeat test till we were convinced that they had understood the lesson. We carried out diet surveys on their families before and after this course and found that some of these children had influenced food-habits for the better in their homes. As mentioned earlier, the effects were greater if both the mothers and children receive nutrition education.

Our practical objectives in the above attempt were as follows:

(a) To create an awareness of the effects of poor nutrition on growth, general health and well-being and of the significance of specific clinical deficiency symptoms.

(b) To emphasize that a combination of cereal plus pulse is superior to that of only cereal and that the cost of such a combination need not be more expensive than that of only cereal as the amount of cereal can be reduced correspondingly.

(c) To emphasize proper cooking methods such as cooking rice by absorption method, not sieving off the bran from atta or to only use a very coarse sieve, to wash vegetables before cutting and to cook them under cover, etc.

(d) To use undermilled or parboiled rice and jaggery in place of refined sugar.

(e) To include regularly leafy vegetables and other carotene rich vegetables and fruits.

(f) To use frequently sprouted legumes and fermented foods.

We also found that very poor mothers, belonging to the families of landless labourers, were unable to benefit from such education because of their poverty. Many of these families bought only cereals, salt and spices and negligible quantities of other foods. Nutrition education is much more successful if the family can spend at least a rupee per day per capita on food.

Other ways of improving community nutrition have been advocated. Fortifying foods such as flour is one of them. Unless these fortified foods are used by the poor or in feeding programmes organized for them, they are not likely to make a significant

impact. Enrichment of flour has met with success in western countries only because the flour is produced and distributed by the food industries organized on a large scale which makes it possible to enforce legislation regarding the enrichment of refined flour. The cost of the flour sold is also well within the purchasing capacity of the people. As stated earlier, conditions are somewhat different in this country. The difficulties in such programmes can be imagined if we consider how far we have succeeded in distributing iodised salt in goitre areas. As compared to cereal whose consumption is 400 g per day per capita, salt consumption is only 10-15 g. The population affected is only 10 per cent. Salt is produced only in selected areas and is supplied to the goitre areas from outside whereas in most parts of the country cereals are locally produced and consumed. Preparation of iodised salt is a much simpler and cheaper process than enrichment of flour. There are no serious problems regarding the keeping quality of salt whereas enriched flours do not have the keeping quality of whole grains. In spite of the relative ease with which salt can be fortified and distributed and in spite of the fact that only 10 per cent of the population living in goitre areas needs iodised salt, we have succeeded, distributing the same, for only 22 per cent of the population affected. If cereals have to be enriched the magnitude of the problem will be at least 250 times that involved in fortification of salt with iodine after taking into account the population affected and the amount required.

It has been said that nutrition education is a costly and time-consuming process. It can be seen from the foregoing that enrichment schemes are not likely to be less so. If we make a concerted approach at nutrition education through schools, training colleges, village leaders, health personnel, women's organizations and the like, we can make an impact on at least 25 per cent of the people receiving instruction. Nutrition education has to be given only once whereas enriched foods have to be made available on a long-term basis. It would, therefore, appear that nutrition education need not be more expensive in the long run. If at least one teacher in each school receives adequate training in nutrition and is responsible for teaching the subject in the school in a realistic way and also makes efforts to reach the community, an impact should be soon felt.

If panchayat leaders receive similar training it will make the

promotion of welfare measures easier.

If we wish to reach a large segment of the population, we can attempt this through special workers trained in nutrition. A public health nurse whose opinion on health is respected by the villagers might prove a suitable agent for this purpose. However, her duties are so diverse that unless she has only a small population to cater to, it will not be possible for her to take up nutrition education as well. Alternatively, nutrition workers can be appointed at the rate of two for five villages. They can move to another set of five villages after having covered these in one or two years. It is our experience that such field work is done better by a team of two than a lone worker. Two workers can cover a population of about 80000 in two years or 400000 in ten years. To cover the entire population in rural areas, we should need about 10000 workers who would cost Rs. 30 million by way of salaries. Even after allowing for the cost of training, facilities, etc., our budget should not be anywhere near the estimate of Rs. 4000 million for enriching the food of children below the age of six years, according to plans prepared by the Nutrition Advisory Committee in 1968.

It has been argued that we have been trying nutrition education for the last several years and failed. This is primarily because those concerned have been asking the people to do the impossible. We have been proclaiming from our ivory towers the excellent nutritive value of foods such as milk, fish, eggs, oranges, etc., which are beyond the reach of most people. Charts prepared by a health department show prominently cheese and beef as sources of nicotinic acid in a country where either is consumed only by negligible sections of the population. When the author was associated with the Applied Nutrition Programme in 1964, she was shocked to find the gap between diets usually recommended and the purchasing capacity of the people. We have been trying since 1964 to formulate and evaluate diets based on foods available in villages. Our experience has shown that when dietary advice is simple and practicable and requires only minor modifications of the existing diet without increasing the expenditure on foods, it is likely to be accepted.

Food Fads

Poor availability of nutritious foods is an important factor in

malnutrition. But even available foods are not utilized fully because of wrong beliefs.

Many foods are excluded during late pregnancy and early lactation. The absurdity of these fads will be evident when we find that the foods avoided by one group are those recommended by another group. In Gujarat, perfectly healthy and valuable foods such as dals, leafy vegetables, rice, curd and fruits are avoided by the nursing mother. In Madras, on the other hand, rice, curd, leafy vegetables such as amaranth, and betel leaves are considered a "must". In Gujarat, halwa (sirrah) prepared from cracked wheat is given soon after delivery whereas in Madras, wheat is avoided and the mother kept on liquid diet for two days after delivery and given solid foods only on the third day.

Child birth involves loss of body fluids. In addition to the loss of blood most women sweat profusely at the time and suffer from dehydration unless they drink enough water. In both, Gujarat and Madras, drinking water is considered harmful. The author knows at least one case of a mother developing fever due to dehydration. Fortunately, most mothers drink water stealthily, as they are unable to bear the thirst. Education is needed on the fact that boiled water is perfectly safe in almost any condition.

Also ghee is associated with mysterious strength giving properties. Although it is all right as an item in the diet, where the money to be spent on food is limited, it is not a good buy. The amount of money spent on getting an extra 25-50 g of ghee can be usefully spent in other ways. We can get for much less than the cost of ghee and oil 50 g of dal and 50-100 g of leafy vegetables. Similarly, honey and almonds are believed to have mysterious qualities and both are expensive. A much better buy can be made for money spent on these items.

Papaya is believed to cause abortions and some women hopefully take kilograms of the stuff without effect. The unfortunate thing is that many women avoid taking this very nutritious fruit during pregnancy.

Similarly, jaggery is believed to heat up the system, whatever that may mean. Most foods are burnt in the body giving heat. Our ancestors might have cautioned against the excessive consumption of sugar which in those days was available only in the form of crude sugar in jaggery. They had nothing to say about refined

sugar because there was none in their time. This has given rise to the present notion that jaggery is harmful whereas refined sugar is all right. On the basis of their composition, jaggery and palm sugar are preferable to sugar and we have recommended their use in the place of sugar in community feeding programmes.

In south India, wheat is believed to be heat-giving and to be harmful unless it can be taken with large quantities of milk. Wheat is the major component of the diet of the poor in Uttar Pradesh who do not consume much milk and who are not any less healthy than south Indians.

Bananas are believed to result in convulsions in children and even death. The young child does get mild stomach upsets if unripe banana is given, but fully ripe bananas can be mashed and given.

Similarly, pulses are excluded from the diet of children whereas many studies have shown they have no difficulty in tolerating well-cooked pulses.

Potatoes, pumpkin, etc., are believed to result in flatus (gas) particularly in children and nursing mothers. Potatoes form the staple food of the poor in Ireland and as stated earlier its prolonged consumption is not associated with any harmful effect. The belief regarding pumpkin is prevalent in Madras but not in Maharashtra which shows how baseless it is. Yellow pumpkin is a rich source of carotene and many young children, nursing mothers and others will benefit from consuming the same.

Buttermilk is believed to result in sore-throats and is avoided by persons having a cold. While very sour buttermilk causes a mild irritation in some people, fresh buttermilk is a refreshing wholesome beverage.

Pepper is believed to stimulate blood formation. It is also believed that a diet lacking in spices is not easily digested. Both these beliefs have no foundation in fact.

To give a classic example of how wrong beliefs can deprive us of valuable foods, tomatoes were once considered poisonous till someone dared to taste it. Now it is a vegetable which has versatile uses. Ghee is believed to be more easily digested than til oil, and the latter, more easily digested than groundnut oil. While these fats differ in their fatty acid composition, there is no appreciable difference in their digestibility.

It is popularly believed that ladies' fingers okra and fish are good for the brain since they contain liberal amounts of phosphorus needed by the brain. Ordinary diets are certainly not deficient in phosphorus and phosphorus in these foods can hardly improve brain function. The author is reminded of Mark Twain, who was asked by a young literary aspirant as to how much fish he should take in order to improve his skills as a writer. Mark Twain replied that if fish does improve brain function, a medium-sized whale should be enough for the aspirant, judging from his literary standards.

In south India, buffalo-milk is believed to make a person lethargic and dull. The baselessness of this needs hardly to be pointed out.

It is not surprising that man should have an instinctive suspicion of anything strange (this includes foods, people and other matters) but it is indeed surprising that such beliefs have persisted for such a long time without any basis and in the face of evidence to the contrary.

A nutrition worker should seek to remove erroneous and harmful beliefs regarding foods.

The common man deprives himself healthy foods because of wrong beliefs. We are now witnessing another phenomenon in the educated classes who have become highly concerned about their nutritional status largely because of newspaper features on malnutrition and its high prevalence and consequences. This has made them an easy prey to the designs of the commercial food manufacturing industry. For instance, it is all right to take a malt beverage such as bournvita if one does not like plain milk and can afford the stuff, but it is not going to help anyone excel in sports or studies. A certain milk food is claimed to contain 24 nutrients as against 9 in milk. Milk is deficient only in iron and vitamin C which can be provided by relatively cheap foods in the ordinary diet. Glucose is advertised as the fuel used by the brain which is true enough. Except when an individual is starving, glucose supply to the brain is no problem as any carbohydrate is converted to glucose in the body. Even the newborn infant can get its glucose from sugar and milk. Glucose biscuits are not more nutritive than chapaties. They may merely be convenient to have around. Corn flakes are advertised in the west as having all the energy of `sun-soaked' corn which is perfectly true as all the food energy we get

is ultimately derived from solar energy trapped enough during photosynthesis, but corn flakes contain no more solar energy than corn or other grains and are in fact less nutritive because of the destruction of lysine. A number of families use high protein beverages and snacks not because they like them but because they consider them good for health although protein deficiency is not a problem in the educated classes who consume enough of milk and pulse and for the cost of these foods, other more palatable and nourishing foods can be obtained. Now the deficiency of lysine in cereals is exploited to popularise lysine-added breads, biscuits and tonics although the upper class diet is more than adequate with regard to lysine. These examples can be multiplied. It would be better for news media to create not only a concern but also knowledge about nutrition so that the public do not spend their hard earned money on foods that they do not need and do not particularly relish.

3
Soyabean : The Wonder Food

Introduction

Soyabean is often described as a wonder seed. With its rich protein content and ability to grow in diverse and adverse ecological conditions, soyabean in the Indian context can become a miracle seed. The rich protein content of soyabean can create for it an almost unlimited market in India, characterized by severe protein deficiency. The opportunity provided by soyabean cultivation to the farmers of Malwa region to take a more rewarding cash crop in place of traditional, low yielding subsistence crops, led to the rapid expansion of the area under soyabean. In Madhya Pradesh, the area under soyabean increased from a negligible area to almost 1.2 million hectares within the span of a decade, and the production of soyabean from a few thousand tonnes to nearly 0.7 million tonnes.[1] The cultivation of soyabean has spread very rapidly in the Malwa region. Soyabean is cultivated either on kharif fallows or has substituted low value kharif crops, making its cultivation a new source of income for the Malwa farmers. Its cultivation also provided the opportunity for local farmers to utilize their labour power more effectively. Soyabean cultivation also contributed to the enrichment of the soil as it fixed nitrogen to the soil.

The introduction of soyabean in the cropping pattern of Malwa region became a stimulant for increased agricultural income, and this harbingering change in the socio-economic life of the people. The main objective of this study is to understand the pattern of these changes.

The study also seeks to understand :

(a) Geographical, Ecological, Agronomic, and other related factors which facilitated the development of soyabean cultivation in Madhya Pradesh;

(b) Changing cropping pattern created through the introduction of soyabean;

(c) Administrative support for the development of soyabean cultivation;

(d) Level of knowledge of farmers about various practices for optimum cultivation of soyabean;

(e) Cost-return analysis of soyabean cultivation;

(f) Assessment of the socio-economic impact of soyabean cultivation on the cultivators.

Data required for the study was collected through different methods. These included library study of published works on soyabean cultivation and its development in India, discussion with officers associated with the implementation of soyabean development programmes, and interview of a sample of 150 farmer respondents cultivating soyabean and 75 farmer respondents not cultivating soyabean.

Methodology

Indore district was selected for the study, as soyabean cultivation was started quite early in the district, and its cultivation also has become widespread there. Within the district, the study was conducted in the Indore block.

As the objective of the study was to assess the socio-economic consequences of soyabean cultivation, a comparative approach of comparing the socio-economic characteristics of those who cultivated soyabean during the Kharif season, and those who continued the cultivation of traditional crops, without cultivating soyabean, was followed in the study. Keeping in view the limited resources available for the study, it was decided to take a sample of 150 farmers, cultivating soyabean and 75 farmers not cultivating soyabean. The basic approach was to compare the characteristics of these two groups and from this comparison to infer how the socio-economic life of a section of the community taken to soyabean cultivation was influenced by it.

Selection of sample was made on the basis of two staged stratified random sampling procedure. At the first stage, a sample of villages were selected. For this purpose the size of the population in all the 146 populated villages of Indore block was collected. Based on this information, the 146 villages were categorised into small villages (population upto 300), medium sized villages (population 301-750) and large villages (population above 750). Among 146 villages, 36 were small, 60 medium, and 50 large villages. From these villages, 5 per cent of the villages were selected randomly, proportionate to the number of small, medium and large villages. This resulted in the selection of two small villages, three medium villages and two large villages. From the list of small, medium and large villages, the required number of villages were randomly selected with the help of random number tables. The small villages selected were Sindodi, and Khatri-Kedi; the medium ones Umrikedi, Jamniya Khurd and Rinjlay; and the large villages selected were Rangvasa and Kampel.

At the second stage, the sample of farming households were selected. For this purpose, details of the number of farm households cultivating soyabean, and those not cultivating soyabean, and the extent of land owned by them in the seven villages were collected. The farm households cultivating soyabean formed the population for selecting the sample of 150 respondents; and the farm-households not cultivating soyabean constituted the population for selecting the 75 sample of farmers not cultivating soyabean.

The farming households were further classified into marginal (less than 2.5 acres), small (2.5 to 5 acres), medium (5 to 10 acres), and large (10+ acres) farmers, on the basis of their landholding. The sample of farmers cultivating soyabean (150), and those not cultivating soyabean were selected from the lists of appropriate categories of farmers for each village, in proportion to the number of farmers belonging to each of these four categories. When the actual field work was conducted the data presented by the patwaris on non-soyabean growers were founded to be incorrect. In some of the cases, it was found that some of the respondents have cultivated soyabean for few years and then gave it up due to some problems. Such cases were eliminated and replaced by the next immediate one from the list of non-soyabean cultivators. Among the 150 soyabean cultivating respondents, 23 were marginal farmers, 40 small, 51 medium and 36 large. Among the 75 farmers not

cultivating soyabean, 15 were marginal, 22 small, 27 medium and 11 were large.

Information from the selected respondents was collected through an interview schedule in December, 1987. For this purpose, the interviewers stayed in the villages, visited the respondents in their households, and recorded the information obtained from them. Their socio-personal characteristics may be briefly seen.

Social Background

In Table 3.1 the Varna, Caste, and educational characteristics of the two categories of respondents are given in a comparative framework. This would give an appreciation of the distinctive characteristics of farmers who farmed soyabean, apart from those who did not raise it.

It is seen from the percentage of respondents belonging to those cultivating soyabean and those not cultivating it, that apparently there is not much variation in the Varna background of farmers belonging to the two groups. In both groups farmers belonging to Kshatriya Varna predominated.

Table 3.1

Percentage of Farmers Cultivating and not Cultivating Soyabean with Different Socio-economic Background

	Characteristics	*Soyabean Cultivators (N = 150)*	*Soyabean Non-cultivators (N = 75)*
	1	2	3
A.	*Varna*		
	1. Brahmin	7	7
	2. Kshatriya	63	60
	3. Vyshya	16	11
	4. Sudra	8	21
	5. Harijan	6	1
B.	*Landholding*		
	1. Marginal Farmer (less than 2.5 acres)	15	20
	2. Small Farmer (2.5-5.0 acres)	27	29
	3. Medium Farmer (5.1-10 acres)	34	36

(Contd.)

1	2	3
4. Large Farmer (10+ acres)	24	15
C. *Education of Respondents*		
1. Illiterate	46	64
2. Primary School	18	7
3. Secondary School	17	17
4. High School	13	11
5. College	5	1
D. *Education of Respondent's Father*		
1. Illiterate	87	86
2. Primary School	11	13
3. Secondary School	2	—
4. High School	—	—
5. College	—	—
Total	100	100

Comparison of the landholding pattern of the two categories of farmers indicates that farmers with marginal, small, and medium landholdings are more among non-soyabean cultivators, while those with large landholdings are more among those who cultivate soyabean. This means that larger farmers have taken to soyabean cultivation on a larger scale. Fifty-eight per cent of farmers who cultivate soyabean are medium and large farmers owning more than 5 acres, against 51 per cent among non-cultivators. On the other hand, small and marginal farmers constitute 49 per cent among non-cultivators, against 42 per cent among the cultivators. The 150 cultivator respondents owned 1,343.3 acres of land, giving an average landholding of 9.0 acres per household. Compared to this, the average landholding of the non-cultivators was 5.7 acres.

In Table 3.2, the area of land irrigated, sourcewise, is given. Irrigated area formed 45.3 per cent of the land owned by the cultivators of soyabean, against 38.3 per cent of those not cultivating it. In the case of both the groups, the main sources of irrigation are tanks and wells, forming 75 per cent of the irrigated area in the case of cultivators, and 79 per cent of the irrigated area in the case of non-cultivators. Even though the area under irrigation is currently a more in the case of soyabean cultivators, this might have been the result of investments made by them after taking soyabean cultivation. The higher incomes earned through soyabean

cultivation might have enabled more farmers to invest a portion of their income in building irrigation facilities.

The educational levels of the respondents and their fathers were examined (Table 3.2). Little variation was found in the educational level of fathers of respondents cultivating soyabean and not cultivating it. Eightyseven per cent of the fathers of cultivators and 86 per cent of the fathers of non-cultivators were illiterate; and 11 per cent and 13 per cent of them, respectively, had primary school education.

Table 3.2
Area of Land Irrigated by Cultivators and Non-cultivators of Soyabean

Sources	*Cultivators*		*Non-cultivators*	
	No.	*Area (ac.)*	*No.*	*Area (ac.)*
Total	150	1343.3	75	427.7
Canal	0	0	0	0
Tube-well	20	153.0	8	0
Tank/Well	86	455.3	29	129.5
Total irrigated	106	608.6	37	129.5
Percentage irrigated		(45.3%)		(38.3%)

Compared to this similarity, substantial variation is noted in the educational background of respondents cultivating soyabean and not cultivating soyabean. While the percentage of illiteracy among those who did not cultivate soyabean was 64, it has come down to 46 per cent among those who cultivated soyabean. Those with primary school level of education among the cultivators and non-cultivators were 18 and 7 per cent; secondary school 17 per cent in both groups; and high school and higher education 19 and 12 per cent. Thus farmers who cultivate soyabean have distinctly higher level of educational background. By and large, it is farmers with more education and with larger landholdings who have taken to soyabean agriculture.

SOYABEAN : ITS IMPORTANCE FOR INDIA

Soyabean has traditionally been a crop of the East. It is believed

that its cultivation was initiated in about 1,100 B.C. in north-eastern China. As soyabean was abundant in protein of the highest quality, and could grow well in soils too depleted to support other crops, and its cultivation enriched the soil by fixing nitrogen, it became a boon to Chinese farmers over-tilling the soil for centuries. In course of time, soyabean spread from centre of its domestication in China to other parts of China, and subsequently to adjoining countries like Korea, Japan, etc. It was taken to Europe by a Swedish biologist in 1737, and to America in 1765 by an American merchant.[2]

The antiquity of soyabean in India is rather unknown. It might have been introduced into India in the eighteenth century. Its cultivation remained confined to small packets in north India, like the hilly areas of Uttar Pradesh, Punjab, Himachal Pradesh, and some parts of Central India. In Kumaon and Garhwal regions of the Himalayas, soyabean was grown on a limited scale under the name of *Bhati.* An indigenous variety of soyabean, called black soyabean *(kalitur),* has been under cultivation in Malwa region of Madhya Pradesh for several decades. In spite for such an early start, the crop failed to spread to other parts of the country and to make an impact on Indian agriculture. Reasons like the poor acceptability of known varieties, low yields, long duration for maturity, shattering of seeds, etc., adversely affected its production. Apart from these, lack of awareness of the nutritive value of soyabean limited its use of human consumption. In Malwa, soyabean was cultivated mainly as a cattle feed.

In China, Japan, and other parts of the world where Mongolian culture had penetrated, soyabean had become an essential part of human diet for the last several millenia. According to Chinese tradition, *tofu,* or soyabean curd, was invented in China about two thousand years ago. Soyabean was also prepared and consumed by the Chinese and others in various other forms. The nutritional importance of soyabean in the West was first brought to light by French scientists in the 1880s, when they reported that soyabean, unlike other beans, contained virtually no starch, making it eminently suitable for diabetic patients. Over the next several decades, nutritionists brought to light its various other characteristics like digestibility, aminoacids, vitamin and mineral content, alkaline-acidic balance, high protein content, and various other dietary attributes. Such characteristics made soyabean probably the most nutritious food item in nature.

Till 1940, soyabean was a hay crop in U.S.A., and the acreage harvested for hay was equal to that harvested for beans. Since then the acreage harvested for hay decreased steadily; and after 1956 only a small acreage under soyabean was harvested for hay. Along with this decline, the acreage under soyabean for beans steadily increased, and by 1961 an estimated 27 million acres of land were under soyabean. Such rapid increase in the acreage under soyabean has been unique among the major crops in the United States.[3]

The discovery of the nutritive characteristics of soyabean did not stimulate the rapid spread of its cultivation in the West. Instead, it was the opportunity for export of soyabean to China and other Eastern countries caused through drastic decline in Chinese soyabean production in the wake of the Second World War which provided the first stimuli for soyabean cultivation in U.S.A. This was followed by the increased demand for soyabean and its cake as a cattle feed stimulated through increased demand for livestock products brought about through economic development, and rise in per capita income. The need to feed livestocks with nutritious foods gave a fillip to soyabean cultivation in U.S.A. As a result, between 1945 and 1985, soyabean harvest in U.S.A. increased by 11 times. Soyabean became the most important cash crop in U.S. farmers, and the country's leading agricultural export.[4]

In course of time, soyabean became an important component of human diet in the West also. Its oil has become an important vegetable oil used for human consumption. Soyabean is also converted into directly consumable items like ice-creams, dairy whitener (milk). Thus soyabean has become an important component of the diet of people both in Western and in the Eastern parts of the World.

As a food item, soyabean is of great significance to India. As the per capita income of the population is low, Indian diet is predominantly vegetarian. Due to the limited capacity of the population to consume non-vegetarian food items, the main source of protein is from pulse. In Table 3.3 the details of per capita availability of cereals and pulses in India from 1970 to 1986 are given. While per capita daily availability of cereals increased by 8 per cent, the per capita daily availability pulses decreased from 51.9 grams to 40.6 grams (22%). The nutritional requirement of pulse in the Indian diet is 70 grams a day, and against this, the availability of 40.6 grams reflect a very serious deficiency of

protein in Indian diet. Being a pulse with 40 per cent protein in it, the production and consumption of soyabean can greatly contribute to bridge the protein gap in Indian diet.

Table 3.3
Per Capita Per Day Availability of Cereals and Pulses in India, 1970-86

Year	*Population (million)*	*Net production of food grains (million/tonnes)*	*Cereals (grams)*	*Pulses (grams)*	*Edible oil (kgs.)*
1970	538.9	87.06	403.1	51.9	3.0
1971	551.3	94.87	417.6	51.2	3.5
1972	563.9	92.02	419.1	47.0	3.0
1973	676.8	84.90	380.5	41.1	2.4
1974	590.0	91.58	410.4	40.8	3.4
1975	603.5	87.35	365.8	39.7	3.3
1976	617.2	105.91	373.8	50.5	3.5
1977	631.3	97.27	386.3	43.3	3.2
1978	645.7	110.61	422.5	45.5	3.8
1979	660.3	115.41	431.8	44.7	3.8
1980	675.2	95.99	379.5	30.9	3.7
1981	690.1	113.39	416.2	37.5	3.8
1982	705.2	116.63	414.8	39.2	4.9
1983	720.3	113.33	396.9	39.5	4.4
1984	735.6	133.33	436.1	41.8	5.5
1985	750.9	127.35	415.9	38.1	6.0
1986	766.1	131.66	437.5	40.6	4.0

Source : Government of India, *Economic Survey*, 1986-87, pp. 515-16.

Table 3.4
Nutritive Value of Different Food Items

Food	*Protein (per cent)*	*Carbohydrate (per cent)*	*Fat (per cent)*	*Calorie per lb.*
Soyabean	40.0	24.6	20.3	2100
Meat	`24.0	24.0	2.5	576
Egg	14.8	—	10.5	720
Gram	19.0	54.0	4.3	1530
Wheat	12.0	73.7	1.7	1750
Rice	7.5	82.0	1.8	1384
Maize	10.0	73.0	4.3	1700

Source : C. Gopalan *et. al.*, *Nutritive Value of Indian Foods*, National Institute of Nutrition, Hyderabad, pp. 59-114, 1976

A comparative picture of the nutritional value of soyabean can be had from Table 3.4 giving the nutritive contents of popular food items in India. Apart from the highest proportion of protein, soyabean also contains all essential amino acids. It is also a rich source of phosphorous and calcium. Soyabean contains vitamins A, B, C, D, E, and K.

Protein deficiency results in both physical and mental retardation. In such a context, soyabean with about 20 per cent oil and about 40 per cent protein content holds a key to make Indian diet nutritionally balanced. Compared to this, the protein content in cow's milk is only 3.5 per cent; and that in common red bean 25 per cent. The protein in soyabean is better than the protein from other sources of vegetables, and is easily digestible. The protein in soyabean is "complete protein" as it supplies in sufficient amount the kind of amino acids required by body for building and repairing of tissues.

Indian dietaries are deficient in proteins and fats of high biological value. It is also deficient in vitamins and minerals of calcium, phosphorous and iron. The excessive amount of starch and carbohydrates contained in Indian diet lower down the co-efficient of digestibility due to their bulk. In such a context, the addition of soyabean to Indian diet will be a great complementing factor.

As soyabean contains about 20 per cent oil, it has the potentiality to make significant contribution to fill the widening gap in the availability of edible oil, experienced in India. Oil provides more than two times the calories provided by carbohydrates and proteins. Moreover, soyabean oil is 85 per cent unsaturated, and cholesteral free, making it a highly desirable vegetable oil. Thus, soyabean has the potentiality to make very significant contribution to fill the critical imbalances in Indian diet, and through it to contribute to the physical and mental development of the population, particularly those in the poorer strata.

As in the case of other countries, soyabean can become an important component of Indian dietary also. Soyabean oil has already become a popular cooking medium. But preparation of various food products with it is limited. It is estimated that only 3 per cent of the soyabean meal produced in the country is used for human consumption. Texturised soya-protein is used in baking. However, Indians do not yet know how to transform soyabean

into other dietary items like the *tofu* of Chinese. As both the oil and the protein fractions are essential requirements of human body, the process of segregating soyabean into these two components, and consuming them separately is an unnecessary expenditure. Therefore, methods have to be developed and spread among the population to utilize whole soyabean, instead of a fraction of it like oil, as utilized at present.

One of the practical ways to utilise soyabean is for soya milk preparation. Soya milk is reported to have been developed in China before the beginning of the Christian era. It can be processed to give milk, curd and cheese. Many other delicious dishes also can be prepared from soyabean. Soyabean can be consumed in green, dry, and sprouted forms. It can be also used in cakes and candles. Its flour can be mixed in bakery products and also for making *Chappati.* However, most of these uses are unknown to Indians. Due to the deficiency in the development of culinary arts in the preparation of soyabean items, only its oil constituting less than one-fifth of the produce is used for human consumption. The remaining portion, constituting more than four-fifths of the produce, is exported as de-oiled cake to foreign countries at very low price. It is a paradox that in a country where protein is acutely and chronically deficient in the dietary of the population, such a valuable item is exported at a throw away price.

The ability of soyabean to grow in adverse ecological conditions is its another important characteristic. It is best grown on well-drained fertile, loamy and clay soils, retaining moisture. But it can survive in difficult environments, and can also withstand adverse weather conditions and moisture stresses. However, soils which are very light and waterlogged are ill-suited for soyabean cultivation. During Kharif, it grows better than many traditional crops like maize, jowar, moong, urad, etc., grown in the black cotton soils of Malwa. In medium and deep soil of high clay content where crops are not raised during Kharif season, soyabean can be efficiently grown.

Black cotton soils of different types are difficult to cultivate in Kharif season. This soil is common in Maharashtra, western parts of Madhya Pradesh, and parts of Gujarat, Andhra Pradesh, Tamil Nadu and Karnataka.[5] In Madhya Pradesh the black soils occupy almost half of the state, covering the Malwa plateau, Narmada valley and Satpura ridge.[6] They vary in depth and are

usually loam to clay in texture. The black soils may be further classified into deep black soils, medium black soils, shallow black soils, and mixed black soils. In Table 3.5, the districts where these soils occur and the area covered by them are given. In Madhya Pradesh black soils occur in about 61 million acres. Apart from cotton, other crops like wheat, sugarcane, groundnut and jowar also are raised on it.

Of the 61 million acres under black cotton soils in Madhya Pradesh, about 19 million acres are under forest, leaving the remaining 41.2 million acres suitable for cultivation.

Table 3.5
Distribution of Different Types of Black Soils

Type of soils	*Areas/Districts of occurrence*	*Area (Acres)*
1. Deep black soil	Narmada Valley, Vindhya and Satpura plateau, especially Hoshangabad and Narsinghpur districts	3.5 million
2. Medium black soil	Malwa plateau, Nimar Valley, Jhalma, Dhar districts	40.0 million
3. Shallow black soil	Satpura ridge, Districts of Seoni, Chhindwara and Betul	7.5 million
4. Mixed red and black soil	East of Gird Region, Bundelkhand and Bagelkhand	10.0 million

The deep black soils of Narmada basin and the adjoining areas are good for wheat, linseed and gram, and rabi cultivation is predominant in the area. In the medium black soils of Malwa and Nimar region, wheat, cotton, sugarcane, jowar and groundnut are the main crops. In the shallow black soils, the main crops are jowar, paddy, wheat, gram and cotton. In the mixed red and black soil region of Bundelkhand and Bagelkhand areas, paddy, wheat gram, jowar, barley, linseed, til, etc., are the common crops. While both kharif and rabi crops are important in areas with mixed red and black soils, in other areas rabi crops predominate. Leaving the mixed soil areas cultivated during the kharif and rabi seasons, there are about 30 million acres of black soil in Madhya Pradesh which are either poorly culivated, or left fallow during the kharif, which is well-suited for soyabean. This is a vast area holding

gigantic potentiality to contribute both to the agricultural production of the country and to farmers' income. This potentiality is either not exploited or only poorly exploited in the absence of a suitable crop like soyabean which can be raised in this area. Similar situation exists in the neighbouring states with vast stretches of black soils.

In Maharashtra,[7] there are vast stretches of land under black soils. Deep black soil is spread over an area of 47,000 sq. kms, (4.7 million hectares) along the courses of Tapti, Godavari, Bhima and Krishna rivers. Medium black soils, covering an area of 2,50,000 sq. kms (25 million hectares), are spread over the districts of West Khandesh, Nasik, East Khandesh, Aurangabad, Ahmednagar, Bir, Sholapur, Osmanabad, Nanded, Parbhani, Buldana, Akola, Amroti, Nagpur, Wardha and Yeotmal. Shallow black soils are found in an area of 4,400 hectares, mainly in Satara district. In the neighbouring Andhra Pradesh, there are vast tracts of land with black soils. They are chiefly found in the districts of Guntur, Kurnool, Cuddappah, Anantapur, Khammam and Adilabad. Though most of the black soils in Maharashtra, Andhra Pradesh, and other states are not left fallow during kharif season, generally low value crops like shorghum, grams, which do not require much labour, is raised in these areas, during the season. While the cultivation of these crops is less labour intensive, the black soils with their sticky character makes it difficult for humans and animals to work in it. In such a context soyabean presents a good substitute crop, which fits eminently into the ecology, yielding high value products having very high nutritional and commercial value. As there are vast stretches of land with black cotton soils, eminently suitable for soyabean cultivation, the scope for extending its cultivation into these areas is almost unlimited. Even with the existing low level of yields, India has the potentiality to become the major soyabean producing country in the world. Apart from this distinction, with the spread of soyabean cultivation to new areas, substantial increase in its production, popularization of its consumption in various forms, will go a long way in making good some of the critical deficiencies in Indian diet.

GROWTH OF SOYABEAN CULTIVATION IN INDIA

Even though certain traditional varieties of soyabean were cultivated in some parts of India for several decades, there has not

been increase in the area under its cultivation, improvement in varietal characteristics, or introduction of better cultural practices. Since the latter half of the nineteenth century, soyabean is known to have been grown in the western parts of Madhya Pradesh as a leguminous crop. Its seed, *Kalitur*, was used mainly for feeding cattle. There was little realization of its nutritive and commercial value. The prevailing soyabean varieties were fodder types, characterized by late maturity and poor yields. The types available in Seoni, Betul and Chhindwara, matured in about 130-140 days, and were trailing, bushy and with heavy foliage. Soyabean cultivated in Malwa were mid-late varieties maturing in 130 days, semi-trailing, and with poor yields.

Kalitur was popular because of its low input technology, low cost of seed, and its keeping quality under ordinary storage conditions. Its main shortcomings were fetching low market price, late maturity, susceptibility to shattering, and low response to fertilizer.

Soyabean grew best on fertile, moisture-retentive, and well-drained soils. The best temperature for its germination and growth was about 30°C. On soils that are low in fertility and poorly drained, it grew better than other kharif crops like moong, urad, maize, jowar. In medium and deep soil of high clay content, where groundnut could not be grown, soyabean could be grown. This made soyabean an eminently suitable crop for cultivation in the black soils during the kharif season.

The Institute of Plant Industry (Agricultural College), Indore, undertook researches on soyabean cultivation in the thirties and forties. But the results of these studies were insignificant, not leading to its popularisation among the farmers. However, some farmers continued its cultivation in the Malwa region as an easy-care crop. Looking at its suitability for cultivation in semi-water logged condition, the Jawaharlal Nehru Agricultural University, Jabalpur, started research work on soyabean right from its inception in 1964 in collaboration with U.S. Universities.

Soyabean Improvement Work

It was the collaborative research between American Universities and the Jawaharlal Nehru Agricultural University, Jabalpur, and Pantnagar Agricultural University, Pantnagar, which

paved the way for the rediscovery of the relevance of soyabean for the Malwa region. Under this collaborative work started in the mid sixties, soyabean was introduced to Indian agricultural scientists by American agricultural scientists, and its breeding and other developmental measures were taken at the two universities.

The early American varieties introduced in western Madhya Pradesh, though superior to native varieties, posed problems of germination and poor resistance to pests and diseases. This necessitated its replacement by improved varieties developed by crossing the native and the American varieties. One of the early varieties of soyabean introduced from U.S.A., was the Bragg variety, having high yield potential and wide adaptability. Clark 63, another variety from U.S.A., which matured in about 95 days, was also introduced in the region with low rainfall areas, as it matured earlier. But it did not become a popular variety due to its low rate of germination, and poor storability. Later, another soyabean variety which matured in 95 days, but was superior to Clark 63, both in yield and germination, was found among the plant material from Garhwal hills. This variety, called J.S. 2, was suitable for different agro-climatic zones of Madhya Pradesh. It was determinate, semi-dwarf, and flowered in about 39-42 days. It was very tolerant to blight disease, stemfly, and girdle beetle, and got a yield potential of about 35 quintals per hectare. Such characteristics considerably popularized the variety. During the unprecedented drought of 1979 JS-2 suffered the least among different varieties of soyabean.

Subsequently, another variety called JS 75-1 was selected from local collections. It had all the good qualities of *Kalitur*, and was devoid of many of its shortcomings. It matured in about 115 days, a week earlier than *Kalitur*. The seed was shining yellow, small, with excellent keeping and germination qualities. It also had a high yield potential of 25 quintals per hectare. It also grew well under drought and late sown conditions. Shattering of the pods of this variety was low and it also offered good resistance to diseases and common pests like girdle beetle and stemfly.

Over the years a number of soyabean varieties were developed by the agricultural scientists. Different varieties were suitable for different soil types. In light soil JS-2 and Punjab-1, which matured within 90-95 days, were suitable. For heavy soils, having good drainage, varieties of medium maturity of 104-106 days liked

Bragg, Gauvarv (JS-72-447), Durga (JS-72-280) were suitable. In deep black soil varieties like Ankur (T. 49) and *Kalitur* derivatives were suitable. As different types of soyabean suitable for different soil types became available, it became possible to rapidly spread its cultivation to areas with divergent ecological conditions.

In early seventies, two projects, *viz.*, "Improvement of the productivity of rainfed areas of Madhya Pradesh" and "Indo-U.K. Dry Farming Project" were started in Indore district to bring about an all sided improvement in the agriculture of the region. These projects tried to increase land productivity by adoption of advance technology for land improvement, soil and water conservation, crop husbandry, animal husbandry, exploitation of underground water, etc. Adoption of improved and high yielding varieties of crops like sorghum, wheat, gram, introduction of new crops like soyabean, and their improved varieties, cultivation of appropriate crops in kharif fallow, and bringing more land under double cropping, increased use of fertilizer, etc., were the important components of these projects. These two projects helped the spread of soyabean cultivation in the region.

As Kalitur continued to be popular with the farmers and was extensively cultivated by them, attempts were made to improve its quality. While Kalitur had undesirable characteristics like late maturity, shattering, lodging, excess foliage, and black seed coat lowering its market value, its main asset was its ability to survive in adverse environmental conditions with low management. In order to improve Kalitur, a large number of crosses were made, leading to the selection of several yellow and black types.

Encouraged by the success achieved in soyabean research and production, the Indian Council of Agricultural Research (ICAR) launched an All India Co-ordinated Research Project on Soyabean in 1967. Jabalpur and Pantnagar continued to be the main centres of the research, but three more centres were opened up at Parbhani, Bangalore and New Delhi. As part of the scheme, twelve sub-centres were also established in different agro-climatic zones of the country.

In Table 3.6 the area under soyabean in different states of the country in 1977-78 is given. Though soyabean is cultivated in several states, Madhya Pradesh accounted for 73 per cent of the area, followed by Uttar Pradesh, contributing to 25 per cent. The area under soyabean in other states like Karnataka, Bihar and

Himachal Pradesh were very negligible, leaving Madhya Pradesh the soyabean state of India.

Table 3.6
Total Area of Soyabean for the Years 1977-80 in Different States of India

States	Target Area (in hectares)	Percentage to Total Area
1. Madhya Pradesh	4,00,000	73.19
2. Uttar Pradesh	1,37,000	25.16
3. Karnataka	3,000	0.55
4. Bihar	3,000	0.55
5. Himachal Pradesh	3,000	0.55
India	5,46,000	100.00

Source : *Soyabean Marketing Information*, J. N. Krishi Vishwa Vidyalaya, Jabalpur, pp. 21-22, 1979.

In Madhya Pradesh soyabean production expanded from early seventies (Table 3.7). Area under the crop increased from a modest area of 0.13 lakh hectares in 1973-74 to 11.2 lakh hectares in 1986-87. During this period the production of soyabean increased from 0.6 lakh tonnes to 7.4 lakh tonnes. The crop became well-established in the cropping pattern of the state, particularly its western, central, and southern districts, with vast areas under black soils. The districts where it is cultivated extensively are Indore, Dhar, Ujjain, Dewas, Shajapur, Sehore, Raisen, Betul, Rajgarh, Hoshangabad, Sagar, Jabalpur, Chhindwara, Narsinghpur, Bhopal, and Vidisha. The area under soyabean in the important soyabean growing districts is given in Table 3.8. Madhya Pradesh has been able to make such rapid progress in the cultivation of soyabean mainly due to governmental effort to popularise its cultivation in various parts of the state.

The progress of soyabean cropping in Madhya Pradesh is the outcome of appropriate planning and extension work, supported by research, marketing and processing activities. Production of soyabean received a boost in the state with the implementation of the centrally sponsored Soyabean Development Scheme. Under this scheme, sanctioned in the year 1969-70 and continued upto 1980-81, soyabean farmers were given improved seeds at subsidized

rates, and minikits containing essential inputs. A large number of demonstration farms were raised. The implementation of the schemes facilitated the substantial expansion of the area under the crop.[8]

Table 3.7
Area and Production of Soyabean in Madhya Pradesh, 1973-74 to 1978-88

S. No.	*Year*	*Area in thousand hectares*	*Production in thousand tonnes*
1.	1973-74	13.36	5.94
2.	1974-75	33.76	14.80
3.	1975-76	43.51	19.82
4.	1976-77	59.86	26.63
5.	1977-78	90.46	42.46
6.	1978-79	198.61	86.76
7.	1979-80	261.71	89.76
8.	1980-81	238.79	96.88
9.	1981-82	307.36	235.13
10.	1982-83	457.75	279.69
11.	1983-84	613.80	461.58
12.	1984-85	986.63	769.57
13.	1985-86	1096.52	828.97
14.	1986-87	1209.55	677.36
15.	1987-88 (As per final forecast)	1319.40	741.50

Source : Office of the Commissioner Land Records and Settlement, Madhya Pradesh, 1988.

In 1980-81, the Government of India sanctioned a Soyabean Development Programme for Madhya Pradesh at a cost of Rs. 15 crores, against the State Government's proposal for a massive Soyabean Development Programme estimated to cost Rs. 36 crores. This programme was implemented between 1981-82 and 1984-85. Under this programme, all facilities given earlier were continued and additional subsidies were given for the purchase of plant protection equipments, chemicals, weedicides and farm implements. On the initiative of the State Government, the Madhya Pradesh State Oil Federation organized co-operative societies for taking up soyabean production in selected districts. Through these co-operative societies quality seeds were supplied to the growers and the soyabeans produced by them were purchased at support

or market prices, whichever being higher. In 1980-81, an amount of Rs. 13.17 lakhs was sanctioned by the State Government under the Soyabean Development Programme, and of this Rs. 8.2 lakhs were utilized. In 1981-82, against a sanctioned amount of Rs. 127.6 lakhs, Rs. 72.9 lakhs were utilized, and in 1984-85, Rs. 340 lakhs were utilized against a sanctioned amount of Rs. 344.9 lakhs. Between 1980-81 and 1984-85, the aggregate utilization was Rs. 810.2 lakhs, against a sanctioned amount of Rs. 1035.1 lakhs. A number of factors have affected the full utilization of the sanctioned amount for spreading soyabean cultivation of new areas. The difficulty of getting large compact areas of 50 hectares made it not possible to lay the targetted number of large scale demonstration plots of 50 hectares each. Due to short supply of soyabean, the quantity of seed supplied at the subsidized rate was less than the target. As the attacks of pests and diseases on soyabean crop was less than the expectation, the expense on pesticides, etc., were less.

Table 3.8
Area under Soyabean in Different Districts of Madhya Pradesh, 1983-84

Districts	*Area (Thousand Hectares)*
Hoshangabad	72
Indore	64
Betul	59
Ujjain	52
Dewas	52
Sehore	42
Shajapur	41
Dhar	38
Chhindwara	38
Rajgarh	22
Narsinghpur	13
Sagar	13
Seoni	9
Bhopal	9

Source : *Agricultural Statistics*, Directorate of Agriculture, Madhya Pradesh, 1984, pp. 61-62.

In 1984-85 the Soyabean Development Programme was merged with the National Oilseeds Development Programme, and the soyabean development programme was implemented in the nine

districts of Indore, Dhar, Ujjain, Shajapur, Dewas, Betul, Rajgarh, Hoshangabad, and Chhindwara. The main strategy identified for increasing production were : (1) area extension, (2) package approach, (3) mass campaign, (4) increased use of rhysobium culture, (5) transfer of technology through demonstrations, (6) minikits for small and marginal farmers, (7) increase of soyabean area under irrigation, (8) provision of adequate and proper marketing facilities, and (9) publicity and training of farmers. During the Seventh Plan, the Madhya Pradesh Government set a target of increasing soyabean cultivation in the state from 10 lakh hectares to 18 lakh hectares, and production of seed from 7.5 lakh tonnes to 14.40 lakh tonnes, and vigorous attempts are made to achieve these targets.

Soyabean being little used for domestic consumption, an essential requirement for the extension of its cultivation is its marketability at reasonable prices. This requires facilities for purchasing the beans, its storage, transportation and further processing into various products fit for human use. Various schemes have been formulated and implemented to ensure these conditions. Support price scheme for soyabean was introduced by the government to ensure the payment of fair and remunerative prices for the producers. As in the case of other crops like wheat, paddy, such a measure was found to be necessary to encourage the farmers to expand the area under soyabean and increasing its productivity. Therefore, the State Government laid down the support prices for soyabean from time to time, and ensured that the farmers could sell their soyabean at this or higher prices. This measure prevented steep fluctuation in soyabean prices, and contributed to steady increase in area under the crop.

The support price for black and yellow varieties of soyabean varied. The support price for black soyabean was Rs. 183 per quintal in 1980-81, Rs. 230 per quintal in 1983-84 and Rs. 255 per quintal in 1986-87. The support price for yellow variety was Rs. 198 a quintal in 1980-81, Rs. 255 a quintal in 1983-84, and Rs. 290 a quintal in 1986-87. In 1980-81, the support price for yellow soyabean was only 8.2 per cent more than that of the black soyabean; but by 1986-87, the difference became 13.7 per cent. The quantity of soyabean procured by the government agencies at the support prices was not very substantial, as the farmers generally got a higher price for their produce in the open market. For

example, in 1986-87 the open market price for soyabean per quintal varied between Rs. 375-465, while the support price varied between Rs. 255-290.

Madhya Pradesh government also encouraged the establishment of a large number of processing units in the state. Apart from three processing plants in the co-operative sector, there are 47 private companies in the State processing soyabean. Their combined processing capacity exceeded 1.2 million tonnes of beans. These plants are basically crushing and solvent extraction units, extracting oil from beans. While the oil, constituting about one-sixth to one-fifth of the beans, is used for human consumption within the country, most of the soyabean cake, with about 60 per cent protein content, is exported to developed countries like Europe. Even though the need for processing and utilizing soyabean protein in the country is greater than that the extracting and using oil, inadequate development of both technology and market has limited the processing of soyabean along these lines. Such a situation has limited the full utilization of soyabean and its products, and also limited the development of a market for soyabean commensurate with its nutritional value. Naturally, the price of soyabean continues to be much lower than what is warranted by its nutritional value. In such a context, development of the technology of soyabean processing, and expansion of market for soyabean and its products and increase in its consumption are necessary for increased utilization of soyabean and its growers receiving higher prices for their product.

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4
Non-vegetarian Food Sources

Milk, eggs, poultry, sea foods and meats are the main foods of animal origin. As stated earlier, animal foods are rich in methionine and are the only sources of vitamin B_{12}.

Milk (Animal Origin)

Milk is the most widely consumed of these foods. Even people who are opposed to taking animal foods obtained by killing, because of either family tradition or personal conviction, do not object to milk, as the same is obtained without killing the animals. However, people such as the vegans in Britain do not include even milk in their diet.

Since early times, man has tamed many mammals and used the surplus milk produced as food. Cows, buffaloes, goats, sheep, camels and donkeys are all used as milk animals. Yaks are used for milking purposes in mountain regions. In this country, cow milk and buffalo milk are the most important from the commercial standpoint. Reliable estimates of the amount of goat milk are not available as most of the milk produced is consumed by the family. It can be used with benefit for those who are either allergic to cow milk or are unable to tolerate it. It is also used in the manufacture of special varieties of cheese. Camel milk and donkey milk are used in desert regions. The latter is also advocated for medicinal purposes.

Milk because of its being the natural food for infants of mammals is a complete food. It is a source of protein and fat

soluble vitamins, and the best source of calcium. It is easily digested and tolerated and is very useful in the feeding of infants and convalescents.

However, milk obtained from animals is lacking in iron and vitamin C. As milk is a food intended by nature for the infant of the species and most of the mammals can synthesize vitamin C it is not surprising that milk obtained from animals is deficient in the same. In contrast, human milk contains liberal amounts of vitamin C, a fact which is consistent with the need of the human infant for this vitamin.

For the newborn infant which is born with a surplus store of iron, a deficiency in milk of iron is of no consequence. But when milk is continued as the sole food after the first six months, the child tends to develop iron deficiency anaemia.

The per capita availability of milk in this country is of the order of 100 g per day. About one-third of the milk produced is consumed in urban areas which contain about 20 per cent of the population. About 5-10 per cent of the urban population consumes more than 400 g of milk per capita per day. Restaurants in urban areas use up a good proportion of milk for the production of tea and coffee. Consequently, a majority of the people, specially in the rural areas, get less than 50 g per day per capita. There are many families which hardly consume any milk.

Milk is the only source of animal protein in vegetarian diets. Generally, the production of animal protein involves extra pressure on the land as about 10 g of protein have to be fed to the animal in order to derive 1 g of protein as food from the animal. In case of dairy animals, however, about 3 kg of plant proteins are converted to 1 kg of milk protein. Further, the dairy animal is able to utilize foods such as hay and grass which are not edible for man and needs only a small supplement of foods which are edible for man. Even these are mostly in the form of oil-cake, cotton seed, cluster beans, etc., which are not used in our diets at present. The dairy animal, therefore, does a very valuable service to man by converting non-edible food to edible food of highest quality and provides in addition valuable manure in the form of dung and urine. In spite of the low yields obtained at present milk compares in cost and nutritive value with other foods of animal origin such as eggs and meat

Milk is used mainly as such or in the form of curd and buttermilk beverages. It is also used for the preparation of ice-cream, milk chocolates, malted beverages and milk sweets such as khoa, peda, gulabjamun, rasgollas, sandesh, etc.

Curd is the major product obtained from milk in this country. Milk is fermented by certain bacteria which convert the lactose in milk to lactic acid which is responsible for the sour taste of curd. These bacteria are introduced into milk by the addition of a little curd from the previously prepared batch. For these bacteria to multiply rapidly, the milk should be neither too hot nor too cold. The curd gets too sour in summer and does not set readily in winter because of variations in environmental temperature. These variations can be avoided by setting curd under standard conditions. The milk should be warm (35-40°) when set (the right temperature can usually be achieved by boiling about one-third to half of the milk to be set as curd and adding it to the remainder. A standard quantity of curd should be added to the milk (about one-half teaspoon per cup, or less, if the curd is too sour) and the container kept insulated in winter by inverting a large pan over it. Under these conditions the curd should set in about 5 hours.

The preparation of curd is an ancient process. The difference in the flavour of curds is believed to be due to those in the micro-organism involved in the fermentation. The presence of Torula yeast is found to impart a cheesy flavour. The curd or yogurt prepared in Bulgaria is prepared with *Lactobacillus bulgaricus.*

The preparation of curd is a way of preserving milk. The growth of acid forming bacteria prevents the growth of other micro-organisms which cause milk to spoil. Many pathogenic micro-organisms including those causing amoebic dysentery do not multiply in curd.

Although there is no difference between curd and milk with regard to nutritive value, some people who are unable to tolerate milk are able to tolerate it in the form of curd. In conditions such as diarrhoea and dysentery, curd is preferred to milk. Preparations such as 'eledona' used in the treatment of dysentery in young children are based on buttermilk powder. Curd prepared at home after boiling the milk and diluted to buttermilk with boiled water is equally suitable and much cheaper.

Buttermilk is obtained by adding water to curd and churning

it or as a by-product in the process of preparing butter.

Butter making is an ancient process and involves the separation of butter from milk in which it is present as an emulsion. This separation is achieved by centrifugation, as in churning, so that the lighter fat layer floats to the top. Either whole milk or cream can be used for the preparation of butter. In households cream is separated as a top-scum or malai which forms when milk is heated and allowed to cool with exposure to air. For a good separation of malai, the milk should be heated till it foams up and then cooled with exposure to air by covering it with a colander or a sieve in place of a lid. The milk should not be disturbed before the malai has set. Milk needed for immediate purposes can be boiled separately so that the remaining milk can be left undisturbed. The milk can be cooled for 3-4 hours (after first cooling to room temperature) in a refrigerator or in a basin or cold water for better separation. The malai can be removed and set as curd and the same pooled every two or three days and churned for butter. The addition of some fresh malai or milk over the top-layer will prevent it from going too sour or getting mouldy. Alternatively, it can be stored in the refrigerator after it has set.

The fermentation of cream before churning brings about its acidification and the easy separation of butter. It also imparts a desirable flavour and aroma to the butter. Butter is also prepared from unfermented cream in creameries. In this case, the micro-organisms are added to the butter to bring about the required flavour.

When butter is prepared from fermented cream the liquid left is buttermilk with a pleasant taste and flavour. Both are poor when cream is allowed to ripen spontaneously without the addition of curd.

The agitation caused by churning exerts an effect similar to centrifugation and brings about the de-emulsification of fat and causes the fat globules to accumulate and form a solid mass at the top. When this layer is largely free from moisture it is removed, squeezed gently to remove liquid and stored in a cool place. Its keeping qualities are better if it is formed into a firm ball and floated in cold water so that non-fat substances are washed off. Standard colours and salt are added to butter for table use.

The churning of butter is easier in winter if warm water (40°C)

is added to the fermented cream initially and cold water added after a layer of butter forms at the top.

Many people find a double egg beater more convenient than the traditional churn. An electric mixer can speed up the process.

The buttermilk obtained during the preparation of butter can be used as such or in soups, khadi (buttermilk sauce), rabdi prepared from flour etc.

In this country, as skim milk is not available the removal of malai yields not only fresh butter and ghee but skimmed milk for those who want to cut down fat consumption. Milk containing about 7.5 per cent fat to begin with is found to contain 5.5 per cent, after cooling at room temperature. When it is removed after further cooling in the refrigerator, the latter contains 3 per cent fat which is quite suitable for most purposes and convenient for those who wish to avoid excess fat in the diet.

As mentioned earlier, ghee is prepared from butter by removing all the moisture. The other non-fat components separate out as cheesy particles. To get ghee with good flavour as well as keeping quality the butter should be heated till all the moisture evaporates. The heat should be turned down towards the end and overheating should be avoided. When it is prepared just right the cheesy particles which separate out are golden brown in colour. The ghee can be strained off and the residue can be added to many dishes to add a pleasant taste and flavour. When ghee is cooled to room temperature, it becomes partly solid, the solid portion having a typical granular structure.

Various forms of milk such as homogenized milk, evaporated milk, and non-fat dry milk are now available in the west. Homogenized milk is obtained by subjecting milk to a temperature of 57-60°C at 1000-5000 lb pressure through a very small orifice and in this process a reduction in the size of fat globules takes place and the milk does not easily form a top scum. With the reduction in size, the number of fat globules increases and there is a corresponding increase in total surface area which increases the absorption of proteins and phospholipids resulting in a high degree of emulsification.

Because of the larger surface area of the fat globules, homogenized milk increases the thickness of certain products and coagulates more easily. The cooking quality of homogenized milk

therefore differs from that of non-homogenized milk when used in puddings etc.

Evaporated milk

The evaporation of milk is accomplished by removing a considerable amount of water from whole milk. After the removal of 60 per cent of the water the product is homogenized and sterilized in sealed cans. The cooked flavour characteristic of evaporated milk is not usually detected in cooked food and improves the flavour of certain foods such as those made with cocoa and chocolate.

Condensed milk

Condensed milk is milk which has been concentrated from full cream milk by removal of its water with or without addition of sugar. The removal of water is achieved at a relatively lower temperature by bringing down the boiling point (which is about 100° at atmospheric pressure) to 55-63° by reducing the pressure. The total milk solids are not less than 28 per cent and milk fat not less than 9.5 per cent.

Toned milk

Milk sold as 'toned' milk in this country is milk with reduced fat content, the reduction being brought about by either partial skimming or by addition of skim milk. Skim milk and fat are also skilfully blended so as to give 'reconstituted' milk.

Dry milk

Dry milk is milk from which most of the water has been removed leaving a fine creamy white powder. It is prepared from whole milk or skim milk, the latter giving a product with better keeping qualities. Non-fat dry milk (skim milk powder) can be used with or without fat to replace fluid milk in a recipe or to enrich the product. It can be either reconstituted or used in dry form. Milk prepared from skim-milk powder forms good curd. In the west, milk powder which readily mixes with water is available but the milk powder available in this country has to be treated carefully as it tends to form lumps otherwise. A thick homogeneous paste should be prepared from one cup of milk powder and cold water. Then about four cups of simmering water should be added and the milk churned well and strained through a tea-strainer or

colander. If the powder has become lumpy, it should be crushed with a rolling pin and sieved before being used.

Pasteurization of milk

Pasteurization of milk is very essential because milk is an excellent culture medium for the growth of bacteria. It can be done by holding milk at 62°C for 30 minutes or flash-heating of milk at 72°C for 15 seconds. Thus pasteurization is simply a process for the destruction of pathogenic or other heat labile species of bacteria. Because of the short period of heat and immediate cooling, losses of nutrients are not significant.

In India surplus milk is used for the preparation of 'rabdi' and khova. Rabdi is made from whole milk which is boiled down to thick consistency and sweetened. Khova is whole milk concentrated in an open pan till a granular solid mass with a low moisture content is obtained. Khova is an ingredient of several Indian sweets. However, these products are sold at a high price. Sandesh is prepared from the cheese separating from whey. The separated cheese is kneaded with powdered sugar and pressed into desired shapes to make 'sandesh'. The kneaded cheese is shaped into balls and steeped in sugar syrup for a few hours to form rasagollas.

Khova is mixed with powdered sugar, kneaded well and shaped into desired shapes to form 'peda'. Nuts such as pistachio are sprinkled on top and the product is coloured.

Khova is mixed with a little flour, curd and baking soda, kneaded well, rolled into balls, deep-fried in ghee or hydrogenated oil at a low temperature and the fried balls put in thin sugar syrup to form gulabjamuns. Saffron and rose-water may be added to the syrup. Hundred grams of the same can be mixed with 20-30 g of maida (plain flour), 20-25 ml of curd and a pinch of baking soda. Milk and baking powder can be substituted for curd and baking soda.

The preparation of khova needed for making gulabjamuns is a time consuming process. Khova obtained from the bazaar is often of poor quality. Gulabjamuns can also be prepared from milk powder. As khova contains about 33 per cent fat and 17 per cent moisture a product resembling khova can be prepared by kneading together 6 parts by volume of skim milk powder, 1-1/2 parts of ghee or hydrogenated oil, (or 7-8 parts of whole milk powder and

a little ghee) 2 parts of curd, 1 part of maida (plain flour) and baking soda or baking powder (1/4-1/2 teaspoon for 3 cups of milk powder). The dough is shaped into balls, deep-fried and put in sugar syrup prepared from 8 parts of sugar and 12 parts of water.

Skim milk powder can also be used in the preparation of ice-cream. One cup of skim milk powder should be thoroughly blended with one cup of previously chilled milk, sweetened, and frozen. The frozen milk should be beaten up, the desired flavouring added and the mixture frozen again.

Cheese is prepared by allowing milk to ferment so as to result in a slight souring of the same. This is achieved by adding the appropriate micro-organisms. The soured milk is heated when the milk protein separates out. This is freed of surplus moisture and used as cottage cheese. It is further fermented to form different varieties of cheese by adding different micro-organisms under different conditions.

Cottage cheese can be prepared at home by adding lemon juice to boiling milk or by boiling milk which has been allowed to sour at low temperature (for instance, in the lower shelves of the refrigerator). Souring of milk at a low temperature results in the multiplication of pathogenic organisms.

Cheese is also prepared from milk by the addition of rennin, an enzyme present in the digestive system of the calf. Some plant enzymes and micro-organisms are also able to bring about a similar change.

The liquid which remains after the separation of cheese is called whey. It contains valuable minerals and vitamins. When cheese is prepared at home, whey can be used for preparing buttermilk or khadi or in soups. Commercially, whey is evaporated to form whey solids which are used as cattle feed. They should prove a valuable supplement to the diet of the poor in developing countries.

Malai can be used in place of cream or milk and butter in cakes, biscuits etc. It can be mixed with milk and churned with an eggbeater till it blends with the milk to make coffee cream.

Basundhi is prepared by heating milk for a prolonged period at a low heat so that some cheesy particles are formed. It is then sweetened, seasoned and served as a dessert.

Milk, curd, buttermilk, milk powder, butter and ghee have versatile uses. Milk and milk products are easy to use, highly relished and well-tolerated by groups such as infants and convalescents. It is not surprising that a prosperous land has been conceived of as one flowing with milk and honey.

Meat

The most common meats in this country are those of goat and chicken. Beef, lamb and pork are used to a minor extent. Among the tribal people many other varieties of meat are consumed but these are not commercially available. These are mostly meat of 'game' animals. Indian cuisine is famous for its chicken curry and 'tandoori' chicken.

Meat is a good source of protein and has the advantage that it has a relatively low carbohydrate content which makes it useful in the formulation of high protein, low carbohydrate diets. The fat content of meat varies considerably. In this country meat is used mostly in the form of curry, kabab or pulavs and occasionally roasted as such.

Contrary to popular opinion a large percentage of people in this country (more than 70%) are not vegetarians by either conviction or family tradition. In practice, however, most of them are obliged to live on vegetarian diets because of economic necessity. In most states, the consumption of animal foods including meat, fish and eggs is less than 5 g per day. It is somewhat greater in areas where fish are available as for instance, West Bengal, Kerala, Mysore and Madras. The poor consumption of meat is because of the fact that breeding of animals for meat production involves more pressure on the land. As stated earlier, about 10 g of protein have to be fed to animals to get 1 g of protein in the form of meat. Also there are strong prejudices against pig meat which is the most easily produced kind of meat.

The cooking of meat makes it tender and easy to chew and allows the digestive juice a more rapid access to the protein. In addition to muscle cells, meat contains some fibrous connective tissue. This fibrous tissue is not as easily digested as muscle protein and makes the meat tough. That is why the meat of older animals which contains more fibrous tissue is not as tender as that of younger animals. When meat is hung for some time, certain acids (*e.g.*, sacrolactic acid, develop due to enzyme action and they

help to soften the meat tissue.

Meat forms a very favourable medium for the growth of pathogenic micro-organisms and as such involves the problem of trans-small fish are converted to fish flour. Fish flour, prepared from whole fish is considered to be a very nutritious food. Also, it does away with the major problem of preservation during transportation. The use of fish flour has been enthusiastically advocated by some people. However, fish flour is not acceptable in chapaties etc., because of its off-odour and colour but acceptable when added to soups, curry, etc., which are highly spiced and disguise its flavour. While fish flour may be a welcome addition to foods that can alleviate malnutrition, the more so because it does not involve more pressure on land, its relative nutritive value as compared to vegetable foods appears to have been overestimated. In animal experiments carried out in this laboratory, the addition of either fish flour or legumes to cereals is found to bring about an equal improvement in nutritive value.

Apart from the seas and the rivers, the reservoirs and tanks used for storing water can be used for the development of fisheries.

There are over 1800 varieties of fish in the Indian waters. They include small fish which are consumed whole and big fish weighing as much as half a ton.

Some experts fear that if we resort to indiscriminate fishing with a view for immediate gain forgetting the needs of long-term survival and multiplication of species, we may annihilate them in a few decades. It would seem necessary to shift the site of fishing operations from region to region, so that each region is left undisturbed for some time and to avoid fishing during the breeding season. The development of good transport, storage and distribution facilities is essential if fishing is to be a popular and successful industry.

Other sea foods such as crabs, oysters and lobsters are also popular. Whales and sharks are also caught occasionally.

By-products such as fish manure and fish oil are obtained from the fishing industry. The oil obtained from the liver of cod fish and sharks is a rich source of vitamin A.

5
Nutrition and Infection in National Development

Why is it that the case fatality rates from measles are often 200 times higher in poor developing countries than in the industrialized countries? The main reason is that the malnourished child is often overwhelmed by the infection whereas the well-nourished child can combat it and survive.

Why is it that so many cases of kwashiorkor develop following an infectious disease and so many cases of nutritional marasmus following gastroenteritis? It is well established that infections result in increased nitrogen loss and that diarrhea reduces the absorption of nutrients from the intestinal tract.

Nutritional status thus has an effect on infections, and infections have an effect on malnutrition. These are most important relationships. In developing countries communicable diseases are extremely prevalent and are a major cause of morbidity and mortality, just as they were in Europe and North America at the turn of the century. The majority of children in most developing countries suffer from undernutrition and malnutrition at some time in the first 5 years of life. The problems of infection and malnutrition are closely interrelated. Yet we tend to introduce, quite independently, programmes to control communicable diseases and other efforts to improve nutrition. It would be much more efficient and effective if the twin problems were attacked together. Success in improving the health and reducing the mortality

of children is dependent both on control of infectious diseases and improvements in their food intake. It would be beneficial if these were combined with family planning programmes. There is increasing evidence to suggest a greater willingness of parents to control their family size when the chances are good that most children born will survive into adulthood. Consideration needs also to be given to providing a stimulating environment for the growing child. The situation in the major industrial cities of Europe and North America 75 years ago was comparable to that in the poorest developing countries today. In New York City in the summer months of 1892, the infant mortality rate was 340 per 1000, and diarrhea accounted for half these deaths. Improvements in nutrition by the use of milk stations and other means and a reduction in infectious disease served to lower these mortality rates by half in a period of less than 25 years. At the turn of the century in Britain, rickets, combined with infectious diseases, was taking a heavy toll in the insanitary, smoky slums of the industrial cities, and measles was very often a fatal disease among children of poor families, presumably because of poor nutrition.

The so-called synergistic relationship between malnutrition and infectious diseases is now well accepted, and has been conclusively demonstrated in animal experiments. The simultaneous presence of both malnutrition and infection will result in an interaction with consequences for the host more serious than the additive effect of the two working independently. Infections make malnutrition worse and poor nutrition increases the severity of infectious diseases.

In experimental animals the interaction between nutrition and infection may not always be synergistic, and at times the reverse situation, known as antagonism, is seen. This occurs in animals with certain severe experimentally induced nutritional deficiencies, in which some infections (especially with certain rickettsiae and viruses) have a less severe effect than in a well-nourished animal. In these cases, the host's poor nutritional status presumably provides an unfavourable environment for the particular organism.

This type of antagonism has not been demonstrated to be of clinical importance in humans, and it is believed to occur rarely if at all. In man, synergism, rather than antagonism, appears to be much more common, especially in relation to the important communicable diseases of childhood and to protein-calorie

malnutrition, which is our main concern here.

Effects of Infection on Nutrition

There are several means by which infection affects nutritional status. Perhaps the most important of these is the fact that bacterial and some other infections lead to an increased loss of nitrogen from the body. This was first demonstrated in serious infections such as typhoid fever but has subsequently been shown to be the case in much milder infections such as otitis media, tonsillitis, chicken pox, and abscesses.

Nitrogen is lost by several mechanisms. The principal one is probably increased adrenocortical activity leading to mobilization of amino acids from various tissues and organs, but especially from muscle. The nitrogen is excreted in the urine, and is evidence of a depletion of body protein.

Full recovery is dependent upon the restoration of these amino acids to the tissues once the infection is overcome. To achieve this, increased intake of protein, above maintenance levels, is needed in the post-infection period. Children whose diet is marginal in protein content or those who are already protein-depleted will have a retardation of growth during and after infections. In developing countries children from poor families suffer from many infections in quick succession during the post-weaning period, and often have multiple infections.

Anorexia is another factor in the relationship between infection and nutrition. Infections, especially if accompanied by a fever, often lead to loss of appetite and therefore to reduced food intake. Other infectious diseases commonly cause vomiting, with the same result. In many societies the mother, and often the medical attendant as well, consider it desirable to withhold food or to place the child with an infection on a liquid diet. This may be rice water, very dilute soups, water alone, or some other fluid with a low calorie density and usually deficient in protein and other essential nutrients. The old adage of "starve a fever" is of doubtful validity, and this practice may have serious consequences for the child whose nutritional status is already precarious.

The traditional treatment of diarrhea in some communities is to prescribe a purgative or enema. The gastroenteritis may already have resulted in reduced absorption of nutrients from food, and

the treatment may further aggravate this situation. These are all examples of how illnesses such as measles, upper respiratory infections, or gastrointestinal infections may contribute to the development of malnutrition.

Intestinal Parasites

With the exception of work done on hookworm and the fish tapeworm, the role of intestinal parasites on nutrition in humans has been inadequately studied. Hoodworm disease, due to infections both with *Ancylostoma duodenale* and *Necator americanus*, is still prevalent in many countries. Hookworms cause intestinal blood loss, and although it appears that most of the protein in that blood is absorbed lower down in the intestinal tract, there is a considerable loss of iron, which is mainly absorbed from the proximal jejunum.

Hookworm disease is a major cause of iron deficiency anemia in many countries. The extent of the loss of blood and iron in hookworm infections has been studied. Daily fecal blood loss per hookworm (*N. americanus*) was reported to be 0.31 ± 0.015 millilitre. It was estimated that about 350 hookworms in the intestine cause a daily loss of 10 ml of blood, or of 2 milligrams of iron. Infection densities much higher than this are not uncommon. In Venezuela, where much of this work was done, iron losses greater than 3 mg per day often resulted in anemia in adult males, and losses of half this amount frequently produced anemia in women of childbearing age and in young children.

The anemia of hookworm disease can be alleviated by diet alone. In general it is desirable both to cure the anemia and rid the subject of worms. However, in some circumstances it may be cheaper and simpler to control hookworm anemia by provision of iron rather than control the infection by anthelminthic medication, improved sanitation, or other means.

The fish tapeworm *(Diphyllobothrium latum)* has an avidity for vitamin B_{12} and can deprive its host of this vitamin, with resulting megaloblastic anemia. This parasite is common in man in only limited geographic areas where undercooked fish is frequently consumed.

On a worldwide basis, roundworm is among the most prevalent of intestinal parasites. In 1947 it was estimated that 644 million people in the world (one-quarter of the world's population)

harboured roundworms. With a great increase in world population and few campaigns to control the infection, the worldwide prevalence is probably higher today.

The roundworm *(Ascaris lumbricoides)* is quite large (15 to 30 centimetres long) so its own metabolic needs must be considerable. High parasite densities, particularly in children, are common in poorly sanitated environments. Although complications of ascariasis can develop, such as intestinal obstruction or the presence of the worm in aberrant sites such as the common bile duct, these are relatively rare.

Little research has been done on the effects of larval migration through the liver, the systemic effects of the pneumonitis that results as the parasite passes through the lungs, or the nutritional effects of the parasite in the intestines. Studies have suggested that *Ascaris* may reduce absorption of both protein and vitamin A. However, well-controlled studies in poorly nourished animals and young children are needed before we can conclude that this ubiquitous parasite is an important factor in the poor nutritional status of so many children who have ascariasis. Similarly, the nutritional significance of *Glardia lamblia* infections has been inadequately studied. It too has been shown to reduce the absorption of vitamin A in children.

Effect of Diarrhea

Many studies have indicated that gastrointestinal infections, and especially diarrhea, are very important in precipitating the onset of both kwashiorkor and nutritional marasmus. Diarrhea is common in and often lethal to, the young child. In breast-fed infants there is often some protection during the first months of life, and so diarrhea is often a feature of the weaning process. This "weanling diarrhea" is extraordinarily prevalent in poor communities throughout the world, both in tropical and temperate zones. The organism responsible varies and often cannot be identified.

Diarrhea was a major cause of mortality in children in industrialized countries up to the beginning of this century, but it now constitutes an infrequent and fairly minor illness, Many factors have contributed to this change, and improved nutrition is one of them.

Several studies have shown that admissions of cases of malnutrition are greatly increased during the season when summer diarrhea is most common. For example, in a report from Iran, admissions of cases of protein-calorie malnutrition were more than double in the summer than in the winter, and this paralleled the incidence of diarrheal disease.

Xerophthalmia is the major cause of blindness in several Asian countries, and is also prevalent in certain parts of Africa, Latin America, and the Middle East. Hospital and community studies indicate that cases of xerophthalmia and keratomalacia are frequently precipitated by infectious diseases each as measles, chicken pox, and gastroenteritis. The exact mechanism of this relationship has not been proved, but it is likely that many infections reduce vitamin A absorption and that some result in a decreased consumption of foods containing vitamin A and carotene.

Effects of Malnutrition on Infection

There is considerable literature to demonstrate, both in experimental animals and in man, that dietary deficiency diseases may reduce the body's resistance to infections. A comprehensive review of this work has been published.

Some of the normal defence mechanisms of the body are impaired and do not function properly in the malnourished subject. For example, children with kwashiorkor were shown to be unable to form antibodies to either typhoid vaccine or diphtheria toxoid, but the capacity to do so was restored after protein therapy. Similarly, children with protein malnutrition have an impaired antibody response to inoculation with yellow fever vaccine. An inhibition of the agglutinating response to cholera antigen has been reported in children with both kwashiorkor and nutritional marasmus.

The injection of vaccines in this manner is a good simulation of an attack on the body by an organism, and it can be done ethically, whereas experimental infections with pathogenic organisms can seldom be justified in human research. These studies provide a fairly clear indication that the malnourished body has a reduced ability to defend itself against infection.

Another defence mechanism that has been studied in relation to nutrition is that of leukocytosis and phagocytic activity. Children

with kwashiorkor show a lower than normal leukocyte response in the presence of an infection. Perhaps of greater importance is the reduced phagocytic efficiency of the polymorphonuclear leukocytes in malnourished subjects. These cells appear to have a defect in their intracellular bactericidal capacity. The mechanism for this phenomenon has now been postulated, and involves lowered adenosine triphosphate levels in the leukocytes of malnourished infants, combined with decreased activity of reduced nicotinamide adenine dinucleotide phosphate oxidase in response to phagocytic stimulation.

Although malnourished children frequently have increased immunoglobulin levels (presumably related to concurrent infections), they also may have depressed cell-mediated immunity. In a recent study, the extent of this depression was directly related to the severity of the protein-calorie malnutrition. Serum transferrin levels are also low in those with severe protein-calorie malnutrition, and often take considerable time to return to normal even after proper dietary treatment.

An interaction of nutrition and infection of quite a different kind results from the effect of some deficiency diseases on the integrity of the tissues. By reducing the integrity of certain epithelial surfaces, notably the skin and mucosa, resistance to invasion is decreased and an easy avenue of entry exists for pathogenic organisms. Examples of this are the cheilosis and angular stomatitis in riboflavin deficiency, the bleeding gums and capillary fragility in ascorbic deficiency, the flaky paint dermatosis and atrophic intestinal changes of severe protein deficiency, and the serious eye lesion of vitamin A deficiency.

Fatality Rates for Measles and Other Infectious Diseases

A dramatic illustration of the effect of malnutrition on infection is seen in fatality rates of common childhood diseases such as measles. Measles is a severe disease with a case fatality rate around 15 per cent in many poor countries, because the young children who develop it have poor nutritional status, lowered resistance, and poor health. In Mexico the fatality rates from measles is 180 times higher than that in the United States. The decline in case fatality rates from measles in North America, Europe, and other industrialized countries has been dramatic over the last century. Differences in the clinical severity and the fatality rates from

measles in developed and developing countries are due not to differences in virus virulence but to differences in the state of host nutrition. In my experience working for several years in African hospitals, it was extremely uncommon to have fatalities from measles in the children of Tanzanian families of moderate income, such as those of hospital employees, during a measles epidemic that was causing considerable mortality among the children of poorer families.

Other common infectious diseases such as whooping cough, diarrhea, and upper respiratory infections also have much more serious consequences in malnourished than in well-nourished children. Mortality statistics from most developing countries show that communicable diseases such as these are the major causes of death. In a visit this year to several African countries in the Sahel, I was told that very few children were now dying a starvation or malnutrition, but that deaths from measles, respiratory infections, and other infectious diseases were still very much above prefamine levels. It is clear that many, perhaps the majority, of these deaths are due to malnutrition. This may seem a moot point for a grieving parent. But for the policy planner and the public health official, it is important to know to what extent morbidity and mortality rates are due, or related, to under-nutrition.

The inter-American investigation of mortality in childhood showed that of 35,000 deaths of children under 5 years of age in ten countries, 57 per cent had malnutrition as either the underlying or associated cause of death. Nutritional deficiency was the most serious health problem uncovered, and was frequently associated with common infectious diseases.

Studies in Central America and South Africa have shown that the poorer the state of nutrition of the child, the more frequent and the more severe his attacks of diarrhea. A report from Colombia showed that the age of the child is also an important factor.

Intervention Studies

There have been relatively few well-controlled intervention studies to demonstrate either the effects of improved diets on infection, or the nutritional effects of control of infectious diseases. Research in the village of Candelaria in Colombia showed that diarrhea declined sharply as a result of supplementary feeding of children. A similar study in a Guatemalan village illustrated a

significant decline in morbidity and mortality from certain common illnesses following the introduction of a nutritious daily supplement for preschool children.

A classical study conducted in the town of Narangwal in the Punjab of India demonstrated the value of combining nutritional and health care in one programme. Children were divided into four groups. One group was given both dietary supplements and health care, two other groups received one of the care programmes, and the fourth group served as control. As far as nutritional status and certain other health parameters were concerned, the combined treatment gave the best results, with nutritional supplementation alone also having a major impact. There was no improvement in nutritional status of the group receiving only medical care but no dietary supplements.

Nutrition, Infection, and National Development

Malnutrition and infections combine to pose an enormous hazard to the health of the majority of the world's population who live in poverty. The ever-present threat is particularly to children under 5 years of age. Many of the children who suffer from both malnutrition and a series of infections succumb and die. They are continually replaced by parents who have a strong desire, and often a real need, to have surviving children. The children who live beyond 5 years of age are not mainly those who have escaped malnutrition or infectious diseases, but those who have survived. They seldom are left without the permanent sequelae or scars of their early health experiences. They are often retarded in their physical, psychological, or behavioural development, and they may have other abnormalities that may contribute to a reduced ability to function optimally as adults and possibly to a shortened life expectation. Other factors influencing the development of these children include a lack of environmental stimulation and a host of deprivations related to poverty.

The challenge to health workers and to development economists, to governments and to international agencies, is how best to reduce the morbidity, mortality, and permanent sequelae that result from this synergism of malnutrition and infection. The answer is not fancy hospitals such as those erected in the capital cities and provincial centres of developing countries, and it does not lie in elaborate manufactured foods such as spun soy protein

or expensive infant formulas. The need is not for overtrained doctors nor for advanced food technology. A huge dent could be made in a huge problem by relatively simple means, if we in the affluent nations could summon up the resolve to make the reduction of deprivation our number one goal, and if the governments of developing countries could accept this as a number one priority. The politicians must be persuaded that attention to these problems is not only highly desirable but will have a political payoff.

The governments in both the developed and developing countries must first decide what "development" really means. Too often in the past, development has been viewed mainly in terms of industrialization, and measured in terms of productive capacity and material output of a country. Indicators of development were gross national product or mean per capita income.

Economists have tended to view improved nutrition and health as welfare questions. But it is now clear that these classical patterns of development often contribute very little to the quality of life of the majority of citizens of any country, and may sometimes aggravate the problems of the poor. We need therefore to ask, What is the purpose of economic development? Who is it for? If improved health and better nutrition for people are not considered in development plans, then one might seriously question whether this really is development.

Developing countries should, of course, strive for overall economic development, and especially for improvement in agricultural development. Support, however, should be given largely to those projects and that type of development that will benefit a large segment of the population, will help reduce inequalities in income distribution, and are likely to improve the nutrition, health, and quality of life of those currently deprived. For example, labour-intensive projects are often preferable to capital-intensive ones, and support for small farmers is more important than that to large estates.

The control of infectious diseases and projects aimed at providing more and better food for people are fully justified and important components of a development plan. By themselves they may contribute to increased productivity and better lives. But an improved infant or toddler mortality rate, a lowered disease

incidence, and a better nourished population are perhaps better indicators of development than national averages of telephones or automobiles per 1000 families, or even than dollars or pesos per capita. Who would claim that development is far behind in China when childhood malnutrition has apparently been almost eliminated, major communicable diseases controlled, and the population increase stabilized? Yet China has very many fewer private telephones or automobiles per family and a much lower per capita income than many countries where malnutrition is common, health is poor, and the population is rising rapidly.

Conclusions

It is not possible here to provide a blueprint for development that includes the objectives of reducing infectious diseases and improving food intake. But it is increasingly realized that health care can be effectively delivered by persons with considerably less training than doctors. There are advantages in having many auxiliary medical workers in widely scattered dispensaries and health centres in villages and rural areas rather than having a few doctors and a hierarchy of supporting staff in hospitals in the principal towns. The majority of common illnesses can be successfully treated by health auxiliaries with simple equipment and a quite limited range of medicines. A health system using auxiliaries can be devised to place much more attention on preventive rather than curative medicine. These same auxiliaries can give immunizations, provide maternal and child health services including family planning, administer simple nutrition programmes, and direct local public health measures.

In a similar way it is now widely accepted that most of the malnutrition in the Third World is due simply to inadequate intake of food. Protein deficiency is not the most important nutrition problem in the world. In most populations where the staple food is a cereal such as rice, wheat, corn, or millet, serious protein deficiencies, although common, seldom occur except where there is also a calorie or overall food deficiency. There has been an overemphasis on the protein problem and too much stress on protein deficiencies with a relative neglect of the first goal of a food policy, which should be to satisfy the energy needs of the population. Most cereals contain 8 to 12 per cent protein and are often consumed with moderate quantities of legumes and vegetables. If calorie

requirements are met on these diets, protein deficiencies usually become uncommon, and are certainly confined mainly to over young children with increased nitrogen losses due to frequent infections. The situation in those whose staple food is plantain, cassava, or some other low protein food may be very different.

The lesson to be learned is that commercial production of relatively expensive protein-rich foods, the amino acid fortification of cereal grains, the production of single cell protein, and several other ventures that a few years ago were offered as panaceas for the world's nutrition problems can only reduce the problem of protein-calorie malnutrition to a very small degree. Similarly, genetic efforts to change by small amounts the amino acid pattern of cereal grains are much less important than increasing the yields per acre of these cereals, and of other food crops.

A modest increase in cereal, legume, and vegetable consumption by children will greatly reduce the prevalence of protein-calorie malnutrition and growth deficits of children in the Third World, especially if combined with control of infectious diseases. Breast feeding during the first few months of life can assure an adequate diet, whereas bottle feeding as discussed elsewhere in this issue is a major cause of diarrhea and nutritional marasmus.

Fairly simple, relatively inexpensive nutrition programmes can be used to control specific nutritional problems, the most important of which are vitamin A deficiency, which is a major cause of blindness; iodine deficiency leading to goiter and endemic cretinism; and anemias due to iron or folate deficiency. For example, xerophthalmia is being controlled in some areas by the provision to all young children every 6 months of a capsule containing 200,000 international units of vitamin A and in other areas by fortification of commonly eaten foods with the vitamin. Vitamin A is a relatively cheap nutrient, and the major cost is in the delivery system. There is no good reason why blindness due to vitamin A deficiency cannot be almost totally eliminated in the world in the next 10 years. Mandatory iodization of salt has been remarkably successful in reducing goiter and the mental deficiency associated with cretinism in several countries. Nutritional anemias could be controlled by using similar rather simple methods.

The control of infectious diseases and the improvement of nutrition both deserve a high priority in development plans and

in international or bilateral assistance to low income countries. They should be instituted together because they will be mutually reinforcing and more economical if provided in a co-ordinated manner rather than separately. Allied to this is the need to provide a stimulating environment for the growing child.

Historical and epidemiological evidence suggests that reductions in infant and child mortality and improvements in health and nutritional status may be prerequisites to successful family planning efforts. In the overpopulated countries of the world, population control deserves a high priority, and parents in all countries should receive assistance to help them achieve their desired family size.

There seems to be clear logic in recommending co-ordinated programmes that have three objectives: namely, to control infectious disease, to improve nutrition, and to make family planning services widely available. These three types of services may themselves be synergistic.

6
Nutritional Value of Vegetables and Fruits

The importance of vegetables and fruits was dramatically brought into focus with the recognition of the role of vitamin C in human nutrition. Barring sprouted legumes, which are not widely consumed, they are the only significant sources of vitamin C in the diet. Salad vegetables and fruits are among the few foods which can be consumed as such without cooking.

Different parts of the plant are consumed as vegetables as shown below :

roots	—	yams, carrots, radish
bulb	—	leeks, onions, garlic
tuber	—	potatoes, sweet potatoes
stem	—	celery, asparagus, banana, amaranth
flowers	—	drumstick, agathi, cauliflower
leaves	—	cabbage, amaranth, colocasia, fenugreek, spinach
pods	—	cowpea, french beans, cluster beans, field beans
immature seeds	—	redgram, peas, bengalgram
immature fruits	—	brinjal, pumpkin, cucumber, tomatoes
mature fruits	—	tomatoes and other fruits

Fruits and vegetables are essentially storage sites where plants

store their reserve supplies of nutrients either for themselves or for their progeny. Fruits vary greatly in moisture, carbohydrate, pectin and fibre content and acidity. As stated earlier, they also vary greatly with regard to vitamin and mineral content.

The acidity of fruits is derived from different acids, such as tartaric acid in grapes and tamarind, citric acid in tomatoes, oranges, mangoes and lemons, and malic acid in apple. These or other acids are responsible for the acidity in fruits such as raw wood apple and different kinds of berries. The acids in fruits are formed from intermediates of carbohydrate metabolism which accumulate in the raw fruit. As the fruits become mature, the activities of enzymes capable of converting these organic acids to sugars increase, resulting in increased sugar content. The sweetness of fruits is mainly due to the presence of sucrose, fructose and glucose, different fruits containing different proportions of the same.

An increased cultivation and consumption of vegetables and fruits is certainly desirable for several reasons. They make for a pleasing variety in the meals. They require less land per capita and their production can give more nutrients per acre than other foods as can be seen from Table 6.1.

Starchy Vegetables

Vegetables can help correct the basic deficiencies in our diet of calories, calcium, iron, carotene and riboflavin. The cultivation of bananas and roots and tuber can help increase our calorie supplies as they give high yields per acre. Leafy vegetables can contribute significant amounts of vitamins and minerals.

In the cultivation of vegetables and fruits as energy sources the yield per acre and nutrient content must be taken into account. Bananas are popular but they have a low protein content. But they have the advantage that they are highly relished and can be eaten as such and are easily digested and tolerated even by children. As such, they form a welcome addition to the diet. Roots and tubers are also good sources of calories. Tapioca, yams, potatoes, sweet potatoes and colocasia roots are used as substantial sources of calories in different parts of the world. Upto 200 g of roots and tubers can be consumed in a day as this will provide only about 10 per cent of total calories. Tapioca gives high yields but its consumption must be along with that of cereals, pulses and oilseeds as they have a low protein content and their exclusive consumption

Table 6.1
Relative Efficiency of Vegetable Foods and Animal Foods as Suppliers of Nutrients from an Acre of Land

Foodstuffs	*Good yield per acre (kg)*	*Approximate amount available per acre (a)*					
		Calories × 10^5	*Protein (kg)*	*Calcium (kg)*	*Iron (g)*	*Carotene Vitamin A (i.u × 10^5)*	*Riboflavin (g)*
Cereals	350	12.0	35	0.10	21.0	3.5	0.35
Pulses	250	8.6	60	0.20	20.0	2.5	1.00
Oilseeds	300	16.5	78	0.15	4.8	1.8	0.90
Milk	360	2.9	11	0.76	0.7	3.6	0.36
Animal foods	20	0.4	4	0.05	0.4	0.1	0.06
Leafy vegetables	5000-10000	24-48	200-400	12.5-25.0	750-1500	3500-7000	5-10
Root vegetables	5000-10000	50-100	100-200	1.0-2.0	30-60	50-100	1-2
Other vegetables	2500-5000	10-20	50-100	1-2	50-100	75-150	1.5-3.0
Fruits	10000-20000	50-100	80-160	3-6	120-240	50-100	2-4
Sugar	2000	80	—	—	—	—	—

* Calculated from figures for yield and average nutrient composition of different food groups derived from values given in food tables for commonly consumed foods.

results in protein malnutrition. The same applies to sweet potatoes. Potatoes seem to be the most suitable as they have high energy value and also contain appreciable amounts of essential nutrients. They form a staple for the poor in Ireland and their prolonged consumption is not attended with any adverse effects. Thus if the cultivation of roots and tubers is considered for meeting part of our calorie requirements potatoes would be a suitable crop. However, elephant yams and wild yams which are grown in this country not only give a higher yield per acre but also have a greater content of calcium, carotene and riboflavin as will be seen from the following data :

	Yield per acre (kg)	*Per 100 g edible portion*					
		Calorie	*Protein (g)*	*Calcium (mg)*	*Iron (mg)*	*Carotene (i.u.)*	*Riboflavin (mg)*
Potatoes	5000-10000	97	1.6	10	0.7	40	0.01
Elephant yams	10000-20000	79	1.2	50	0.6	434	0.07
Wild yams	10000-20000	110	2.5	20	1.0	943	0.47

Elephant yams are a hardy crop. Trials in this laboratory have shown that elephant yams and other root vegetables can be readily incorporated in cereal and legume dishes such as debra, stuffed paratha, dosas, cutlets, steamed dumplings, etc., and can thus be used in feeding programmes organized for children. The recipes can be formulated in such a way that protein calories form at least 10 per cent of total calories and the cost works out to less than 50 paise for 1000 calories. A few selected recipes conforming to these criteria are shown in Table 6.2.

In this connection, tapioca is widely consumed in Kerala resulting in a widespread deficiency of protein malnutrition in children. Wheat which contains more protein is not accepted by the people in this state. Studies in our food laboratory have shown that dishes commonly prepared in Kerala can be made with a mixture of tapioca, bengalgram and wheat so as to provide more than 10 per cent protein calories. These dishes have been subjected to sensory evaluation using subjects from Kerala. Their recipes have been included in Table 6.3. Although products like tapioca macaroni

Table 6.2

Cost and Composition of Recipes Based on Cereal-legume-vegetable Combinations

	Cereal (g)	*Pulse (g)*	*Root vegetable (g)*	*Leafy vegetable (g)*	*Other vegetables (g)*	*Oil (g)*	*Calories**	*Protein calories %*
Debra	75	25	100	50	—	5-10	515-560	12.4-13.5
Stuffed Parathas	75	25	100	50	—	5-10	515-560	12.4-13.5
Dhokla	75	25	100	50	—	5-10	515-560	12.4-13.5
Poora (dosa)	75	25	100	50	—	5-10	515-560	12.4-13.6
Khichri	75	25	100	50	50	5-10	545-580	12.4-13.6
Sambhar rice	75	25	100	50	50	5-10	545-580	12.7-13.6
Dumplings	—	50	100	—	—	5-10	317-362	15.5-17.6
Macaroni	25	25	50	—	—	5-10	297-342	10.3-11.6

* Cost per 1000 calories about 45-50 paise in 1967 and about 50 per cent more now (February, 1974).

have been developed by the Central Food Technological Research Institute, Mysore, education of the housewife in the preparation of such dishes will meet the twin objectives of improving the protein intake and increasing the acceptability of wheat in Kerala. A similar consumption of root vegetables in other parts can relieve to some extent the demand on cereals.

Studies with rats have shown that the addition of yam to a wheat-bengalram mixture in the amounts suggested does not affect the protein quality of the diet.

Leafy Vegetables

As mentioned earlier, leafy vegetables are excellent sources of carotene. In diets based on plant foods they are almost the only good sources of calcium, iron and riboflavin. In studies carried out on rats the addition of leafy vegetables to a mixture of cereal or millet+legume is found to result in an improved nutritional status. In other animal studies such addition is found to promote bone calcification. In our field centre, children fed a wheat bengalgram dhokla with leafy vegetables were found to have a better skeletal development and vitamin A status than those given ordinary dhokla.

Many of the fruit vegetables are good sources of riboflavin and vitamin C.

In the choice of vegetables for increased cultivation and consumption, some attention must be paid to their composition with regard to carotene, oxalic acid, calcium, iron and vitamin C.

Among the leafy vegetables, fenugreek leaves seem to be excellent as their amino acid composition is favourable, the carotene in the same is well utilized and they are rich in iron and do not contain much of oxalic acid. They can be chopped and added to fermented batters of dhokla, dosa, etc., or cooked with greengram or with potatoes and onions. In these forms they are well-accepted although they are a little bitter in taste. Some jaggery can be added if necessary. In our rural centre, young children are found to prefer dhokla with fenugreek leaves to many other foods.

Other leafy vegetables low in oxalic acid are cabbage, coriander leaves, mint, and safflower leaves. The oxalate content of many other leafy vegetables is not available.

Table 6.3
Recipes Based on Cereal-legume-vegetable Combinations

Foodstuff	*Outline of procedure*
Debra	Make a dough with cereal plus pulse flour, finely chopped leaf greens, cooked and mashed potatoes, shape into balls, roll out and bake like chapaties.
Stuffed parathas	Cook and mash the root vegetable and add chopped and cooked leaf greens. Shape into balls and use as stuffing for chapaties. Make the dough with the cereal-pulse mixture.
Dhokla	Let ferment batter of coarsely ground cereal-pulse mixture. Add boiled and mashed root vegetable and chopped leaf greens. Steam in greased plates for 20 minutes, cool, cut into pieces and season.
Poora (dosa)	Prepare a better as above but somewhat thinner. Shallow fry like dosas (pancakes).
Khichri	Cook the cereal, pulse and vegetable together.
Sambhar rice	Dehusked dal or sprouted pulse may be used. In the case of grains other than kodri and rice, 'cracked' grain may be used. Cook the cereal-pulse mixture. When it is almost cooked add the vegetables, tamarind juice, salt, spices etc., and cook again to 'sambhar' rice consistency.
Dumplings	Add boiled and mashed vegetable to bengal-gram flour. Add salt and seasoning and shape into balls. Steam, garnish and serve (can also be used in soups and broths).
Macaroni (cereals may be omitted)	Boil and mash the vegetable and add tapioca flour or pulse flour cooked in simmering water so as to form a dough. Knead, roll into balls, steam, press through a `sev' press, season and serve. This combination can also be used for 'puttu', a common tapioca preparation in Kerala.

Fruits and salad vegetables can be consumed as such and form a welcome addition to foods. Vegetables and fruits of low calorie value have an important place in the diets of persons such as obese people and diabetics who have to restrict their calorie intake. Even in normal individuals the consumption of vegetables and fruits helps move the bowels regularly and prevent constipation.

It is not realized that a liberal consumption of vegetables can reduce the need for other foodstuffs and relieve the demand on cereals. About 250-300 g of vegetables and fruits can be consumed in a meal in the form of 50-100 g of roots and tubers, 50 g each of

leafy vegetables and other vegetables, and 100 g of fruits. In fact, in households including such liberal amounts of fruits and vegetables, there is less demand on cereals and pulses. Thus they should have a sparing effect on foodgrains which are in short supply. We need only to visualise the appearance of the following menus in order to realise how much more attractive and appetising a meal with liberal amounts of vegetables and fruits can be :

Menu including vegetables and fruits	*The routine menu*
tomato juice	
or pumpkin soup	
chapaties	chapaties
dal	dal
mashed spinach	potato or other vegetable
baked or cooked potatoes	
cauliflower with peas	curd
salad or carrots and cucumber	
serving of fruit	
curd	

Although it would seem that fruits and vegetables have to be taken in greater bulk in order to provide the nutrients present in other foods they compare well with other foods as sources of different nutrients if their moisture content is taken into account as their dry weight is only about 1/5 of fresh weight (Table 6.4).

About 2-3 per cent of the cultivated land used for the production of grains, oilseeds, etc., should be used for vegetable and fruit cultivation. Much less is actually cultivated. In Baroda District in Gujarat for instance, less than 1 per cent of agricultural land is used for vegetable and fruit production. This results in a deficient supply in relation to demand. This, in turn, results in high prices in spite of their high yields. Reasons for their lack of popularity with the farmer are the high losses prior to and after harvesting. Losses due to insects, birds, rats and monkeys are heavy. A man who grows vegetables has to find a ready market or perish whereas the cultivator of grains can afford to hoard and sell at higher prices. Facilities for storage, quick transportation and marketing and for refrigeration and canning will improve this state of affairs. Commercial dehydration and canning of vegetables at source is also likely to be useful.

Even at the prevailing high prices of vegetables they compare favourably with other foods with regard to nutrients which can be derived from a rupee's worth of foodstuffs as can be seen from Table 6.5. The time involved in preparing vegetables inhibits many people from consuming them regularly. Most poor people are accustomed to one dish meals. Such one dish meals have been worked out using cereal-legume-vegetable-leaf green combinations which have been described earlier (Table 6.3) and they need to be popularised.

The Use of Vegetables and Fruits

Vegetables and fruits can be consumed in a variety of forms such as soups, juices, salads, etc.

Soups

Soups make an appetising addition to meals and are very suitable for infants and the convalescent. They do not ordinarily form part of the Indian dietary, but preparation of soup is not as difficult as might seem to the housewife. Some simple suggestions for soups are given in Table 6.6.

Fresh buttermilk which is not too sour or coconut milk can replace milk in the recipe given. Fried or toasted bread crumbs or bits of fried papad can be added at the time of serving. Whole green legumes or roasted cowpeas can be cooked and added.

If soups with a fine consistency are desired they can be sieved through a colander or blended in a mixer.

Juices

Fruit juices can be prepared from fruits such as water-melon, rock-melon, chani bor, jamun, phalsa and tomatoes. In the case of tomatoes, add boiling water and keep covered for a few minutes (this is called blanching). Peel off the skin after immersing them in cold water, if necessary, churn with an egg-beater, wooden churn or electric beater to a homogenous liquid and chill with salt and lemon juice added. If desired, add suitable seasoning such as cumin, mint, coriander or ajma. A little sugar may also be added.

The tomatoes can also be homogenized as such without blanching if an electric mixer is available. The same can be used for homogenizing a juice from other salad vegetables such as grated carrots, cabbage, etc. Juicy mangoes can be pre-treated like tomatoes

Table 6.4
Different Foodstuffs as Sources of Selected Nutrients

Foodstuffs	*Moisture content %*	*Approximate amount (g) giving*					
		100 calories	*10 g protein*	*100 g calcium*	*3 mg iron*	*1000 i.u. vitamin A or carotene*	*1 mg riboflavin*
Cereals	10	30	100	330	50	1000	1000
Pulses	10	30	40	125	40	1000	250
Oilseeds	5	20	40	200	200	600	330
Milk	84	125	330	50	1500	1000	1000
Animal foods	75	70	40	700	150	3300	330
Egg	72	60	75	170	150	50	555
Leafy vegetables	90	200	250	40	20	15	1000
Starchy root vegetables	80	100	500	500	500	1000	5000
Other vegetables	80	250	500	250	150	330	1700
Fruits	85	b. 100				d. 100	
			1250	330			5000
		a. 200				c. 2000	

(a) and (b)—fruits low and high in carbohydrate.
(c) and (d)—fruits poor and rich in carotene.

Table 6.5
Nutrients Provided by a Rupee's Worth of Different Foods*

Foodstuffs	Amount (g) per one rupee	Nutrient present in rupee's worth foodstuff					
		Calories	Protein (g)	Calcium (mg)	Iron (mg)	Carotene or vitamin A (μg)	Riboflavin (mg)
Cereals	800	2760	80	240	48.0	280	0.80
Pulses	(other than rice) 400	1380	96	320	32.0	240	1.60
Oilseeds (groundnut)	500	2750	130	250	8.0	180	1.50
Milk (buffalo) †	750	600	23	1580	1.5	225	0.75
Animal foods (mutton)	250	485	50	30	5.0	23	0.68
Egg (hen)	75	125	10	45	1.5	350+270	0.13
Leafy vegetables (amaranth, fenugreek, spinach)	2500	1250	100	6250	375.0	105000	2.50
Root vegetables	1500	1500	30	300	9.0	900	0.30
Other vegetables	2000	800	40	800	40.0	3600	1.20
Fruits	1500	a. 1500 b. 750	12	450	18.0	c. 9000 d. 450	0.30

† Milk containing 5 per cent fat, 3 per cent protein and 5-6 per cent carbohydrate.
(a) & (b) are fruits high and low in carbohydrate.
(c) & (d) are fruits high and low in carotene.
* Based on price levels in Baroda during September-October, 1967. 1 U.S. dollar is equivalent to 7.7 rupees. These levels are used because of the market fluctuations at present, the current prices are about 50 per cent more in the case of most commodities.

and the juice expressed. Such treatment makes the extraction of juice easier. Rock-melon and water-melon can be freed from skin and seed and cut into pieces and homogenized.

Chani bor, phalsa, jamun, etc., can be boiled in water for about 5 minutes under cover, allowed to keep for 10-15 minutes, churned, filtered and sugar and lemon juice added and the juice chilled. Juices prepared from these berries have an attractive colour and flavour.

These juices can also be used as a base for fruit punch. A fruit punch is essentially a combination of lemon or orange juice, other fruit juice, sugar syrup and tea to which aerated water is added at the time of serving. Suitable spices such as cardamom can be added.

Vegetables

Tomatoes, cucumber, carrots, onions, green mangoes, tender coconut, capsicum, lettuce, cauliflower, radish, etc., can be used in different combinations to make salads. Lemon juice, salt, oil, mustard seed (in vaghar), chopped ginger, coriander leaves, cut pieces of coconut etc., make desirable additions. Curd can also be used along with or in place of lemon juice. A sweet-sour salad can be prepared from grated carrots by adding lemon juice, sugar, honey and fruits such as pine-apple, banana, dates and raisins. They are highly popular with children. Boiled beets, potatoes etc., can also be added. The salad vegetables can be sliced (*e.g.*, tomatoes and cucumber) or cut into sticks (*e.g.*, carrots) and served as such.

Fruit salad : As mentioned earlier, fruit should be sliced into a bowl containing lemon juice and sugar. Papaya flavoured in this way is highly acceptable to people who do not like the fruit as such A mixture of fruits can make an attractive fruit salad. The cores and seeds should be removed in apples and pears before they are cu.. If seeded grapes are used, they should be cut into halves with a sharp knife and the seeds scooped out before they are added. Green bananas, pumpkin, potatoes etc., can be boiled and served as a salad with curd, salt or sugar and seasoning added. Ripe bananas can be added to a mixture of curd, milk, honey, jaggery and cream or ghee Black raisins, cashewnuts, cardamoms, walnuts, dates, etc., can also be added.

Baked dishes : Potatoes, sweet potatoes etc. may be baked with their skins. Sweet potatoes can also be boiled, skinned, mashed, brown sugar and butter or ghee added and baked. The same may

be topped with a layer of nuts, sesame seed, raisins, coconut, etc. and flavoured with cardamom.

Chutneys : Mint, corianders and curry leaves, onions, tomatoes etc., can be ground into a paste and seasoned to make a chutney. Additions of tamarind pulp, grated coconut, chana dal roasted in ghee, etc., may be made before grinding.

Chutneys can also be made from vegetables after pan-frying or cooking. Onions, green tomatoes, egg plant, ridge gourd, pumpkin, galka, elephant yam and raw wood apple can be prepared by this method. Tamarind pulp, salt, hing, chillies and jaggery may be added before grinding. Vaghar and lemon juice (in place of tamarind pulp) may be added after grinding.

The vegetables may also be prepared in the following ways :

Method	*Procedure*	*Examples*
1	*2*	*3*
broiled	heat oil in a pan, turn in the vegetable and cook with a sprinkling of water under cover	ladies fingers, cauliflower, potatoes, snake gourd
cooked with dal	cook green gram or red gram to three-fourths consistency, add the vegetable and cook to completion	fenugreek, field beans, onions, cabbage
cooked with coconut paste	cook vegetable and add coconut paste and suitable seasoning	'Aviyal' vegetables, cauliflower, cabbage, greens, tomatoes, etc.
roasted whole	roast and peel the vegetable, mash and season suitably	sweet potatoes, green bananas, brinjals
cooked with tamarind juice	cook the vegetable, mash in the case of greens, add tamarind juice, salt, a little jaggery	pumpkin, ladies fingers, amaranth, spinach, brinjal, drumstick, carrots

(Contd.)

1	2	3
	and seasoning; roasted and powdered sesame or fenugreek, or curry powder can be added depending on the flavour desired	
cooked with tomato juice	tomato juice to be substituted for tamarind juice. Fried onions or coconut paste may be added	roasted and mashed egg plant, a mixture of cauliflower, onions, potatoes, peas and drumstick
cooked with buttermilk	use buttermilk in place of tamarind juice	mashed spinach, amaranth, potatoes
steamed with ground dal	pre-soak dal in water, grind into a coarse paste, add the chopped vegetables, season, steam and turn into a pan containing heated oil and cook for 5-10 minutes.	banana flowers, onions, cluster beans, cabbage, colocasia leaves rolled as rolly pollies with dal paste
cooked with jaggery	cook, mash and cook again with jaggery. In the case of wood apple mash the pulp and add to jaggery syrup	pumpkin, sweet potatoes, carrots, wood apple
cooked in jaggery syrup	steam and cook in jaggery syrup	cut pieces of raw mangoes, green tomatoes
pastries and breads	the vegetables may be boiled together and used as filling in pies and pastries (samosas)	peas, onions, cauliflower, potatoes, cabbage, carrots etc.

(Contd.)

1	2	3
	or in yeast breads. They may be mashed and added to debras	
casseroles	the cooked vegetable can be topped with a layer of cheese and coconut and baked	potatoes, cauliflower, etc.
halwas	cook in water or milk or over steam, mash, add ghee and sugar and continue to cook to a halwa consistency	pumpkin, bottle gourd carrots, sweet potatoes
preserves	cook grated and steamed carrot or cooked pumpkin in sugar or jaggery syrup to a jam type consistency and store. Lemon juice, raisins and spices may be added. Remove surplus juice from blanched tomatoes and cook with sugar	carrots, pumpkin, green tomatoes, ripe tomatoes

7
Nutrition and Children

Introduction

The health of the people is the wealth of a country and nutrition is one of the most important pre-requisites for good health. The nutritional status of the people is increasingly being recognised world over as an important indicator of development of a country. The strength of a nation in 21st century will be determined by how healthy and educated its people are.

The nutrition of infants and young children is causing great concern among scientists and planners these days since child is the chief victim of the interplay of nutritional, socio-economic and health factors that cause malnutrition. Rapid growth and development of the child during this period indicate the need for increased nutritional requirements as compared to the adults. Ignorance about correct feeding practices for the child is one of the important causes of malnutrition among young children.

The theme of "Child Caring Practices" for the nationwide celebration of the National Nutrition Week is most appropriate and timely, as it would enable focussed attention on critical areas like feeding practices for infants and young children, preparation of complementary food from the family pot, health seeking behaviour and care of sick children, hygiene practices and psycho-social stimulation. Reaching basic information on these vital aspects to the people and particularly to the women will empower them to make informed decisions on food, nutrition and feeding practices which is a key to the self-sustainable development model.

Promoting optimum development of the child is the responsibility of every one of us towards our nation. Let all sections of the society like family, health personnel, media, religious institutions, employers, educationists and Government provide support to mothers for breast feeding, appropriate complementary feeding and create an environment for them to give proper child care.

Growth and Development

The term *growth* refers to an increase in size because of cell multiplication; the term *development* denotes an increase in the complexity of function. The latter, for example, not only refers to the increasing ability to metabolize nutrients and to co-ordinate motor skills, but it also refers to the complex mental and behavioural changes that occur. The outstanding fact to remember is that each person is unique in every way. Although many factors influence his life, he is physically, biochemically, mentally, and emotionally like no other person.

Neither growth nor development occurs at a uniform rate. The rapid growth in overall size that occurred in fetal life and during infancy is followed by a long period of very gradual growth that accelerates again in the adolescent years. In organ development cellular growth occurs in three phases: (1) rapid cell division occurs (hyperplasia); (2) cell division slows down but protein synthesis continues so that the cells increase in size (hypertrophy); and (3) cell division ceases but protein synthesis continues for a time with further increase in size.[1] Eventually growth ceases. These phases follow a chronologic schedule for each organ, but the timing of development differs for the organs and tissues of the body. The nervous system shows rapid growth early in life, with the size of the brain having achieved 80 to 90 per cent of its maximum size by the age of four years. However, the complexity of function continues to develop. On the other hand, the growth and development of the reproductive organs are negligible until the beginning of the adolescent years. Since each organ has a critical time for its development, it should be evident that interference with the supply of nutrients at any given period can be serious for the development of specific organs and systems as well as the organism as a whole.

Food Habits and Development

Foods to supply good nutrition are obviously fundamental to the physical growth and development of the child. But food means much more to the individual than nutrition alone. The infant's earliest relationships are associated with food, and throughout the growing years food continues to be a major factor in the development of the whole person. For each person food becomes a language of communication; it has cultural and social meanings; it is intimately associated with the emotions; and its acceptance or rejection becomes highly personal.

Food influences each stage of physical, mental, and emotional growth and development. But the food habits that result are also the consequence of the interrelated personal and environmental factors that surround the individual: the stages of physical and behavioural changes that occur and the rates of change; the widening circle of human relationships; and the economic, social, and cultural factors.

Good food habits have several characteristics. First, the pattern of diet permits the individual to achieve the maximum genetic potential for his physical and mental development. Second, the food habits are conducive to delaying or preventing the onset of degenerative diseases that are so prevalent in American society today. Third, the food habits are part of satisfying human relationships and contribute to social and personal enjoyment. The development of food habits is a continuous process in which each year builds upon what has gone before. The responsibility of parents and all who work with children goes far beyond assuring the ingestion of specified levels of nutrients. It requires the application of knowledge from the fields of human behaviour and development, psychology, sociology, and anthropology.

NUTRITIONAL STATUS OF CHILDREN

Assessment of Nutritional Status

The determination of nutritional status can be made only by specialists qualified to give comprehensive physical and dental examinations, to make bio-chemical studies of the blood and urine, and to evaluate patterns of growth and measurements of body size. A single measurement at a given point in time may be of limited value, but a series of measurements at that time on a

given individual are useful in measuring health status. When such measurements are repeated at regularly spaced intervals, the progress of the individual can be noted; thus, each person serves as his own control.

Height-weight charts indicate whether a given child falls within the range of heights and weights for other children of the same chronologic age, but they do not indicate anything about nutritional status. After all, one does not need a height-weight chart to determine gross obesity or severe underweight. Moreover, the chart could be misused by interpreting deviations of weight to be obesity or underweight, when, in fact, for that individual the level of weight might be entirely appropriate in terms of functioning tissue. Longitudinal-type grids (Wetzel grid) or percentile curves (Stuart-Meredith curves) are replacing height-weight tables for assessment of growth.

Stature is considered to be an important index of nutritional status because it is an indication of how well the individual has been able to achieve his genetic potential. The individual who is short may never have received the essential nutrients in sufficient quantity for the best development of his body, whereas the tall individual gives indication of full development. Mitchel[2] has reported on the changes in stature which occurred in boys and girls in Japan over a 10 year period following the war as compared with a similar group prior to the war. As a direct outcome of an improved diet the stature of the boys and girls following the war was significantly greater; the protein content of the diet was believed to be especially important in bringing about this increase.

Certain physical and behavioural characteristics may be noted by the mother, teacher, or nurse which would indicate that some children should be studied more carefully with respect to the adequacy of their nutrition. The well-nourished child may be expected to exhibit these characteristics:

Sense of well-being: alert; interested in activities usual for the age; vigorous; happy.

Vitality: endurance during activity, quick recovery from fatigue; looks rested; does not fall asleep in school; sleeps well at night.

Weight: normal for height, age, and body build.

Posture: erect; arms and legs straight; abdomen pulled in; chest out.

Teeth: straight, without crowding in well-shaped jaw.

Gums: firm, pink; no signs of bleeding.

Skin: smooth, slightly moist; healthy glow; reddish-pink mucous membranes.

Eyes: clear, bright; no circles of fatigue around them.

Hair: lustrous; healthy scalp.

Muscles: well developed; firm.

Nervous control: good attention span for his age; gets along well with others; does not cry easily; not irritable and restless.

Gastrointestinal factors : good appetite; normal, regular elimination.

Nutritional Status of Children

Numerous studies have shown that the nutritional status of most children in the United States is good. Because some of these studies have been limited to children from middle-income groups, the problems of undernutrition or malnutrition often seemed less serious than they, in fact, are. Longitudinal studies have been conducted by Beal and her associates at the Child Research Center in Denver[3] and by Burke and her coworkers at the Center for Research in Child Health and Development in Boston.[4] These studies have shown that children of a given age set up their individual patterns of growth, which may vary widely, just as their intakes of nutrients vary.

An extensive series of studies on approximately 4000 children 5 to 12 years of age and an equal number of adolescents 13 to 20 years was reported by more than 200 investigators between the years 1947 to 1958.[5] Among the important findings were these: at all ages the nutrient intakes by boys were better than those by girls; elementary-school children more nearly met their recommended allowances than did teen-agers; and the adolescent girl had the poorest record of nutrient intake. Below the age of 12 years, the mean nutrient intake exceeded the recommended allowances except for slightly low calcium intakes by girls. For boys from 13 to 20 years only vitamin C was below recommended standards, but for girls the intakes of calcium, ascorbic acid, and thiamine were seriously inadequate and the intake of protein was moderately low. Many of these studies did not include evaluation of nutritional

status, and the intakes could not be equated with changes in health. In some of the studies a correlation was found between the dietary intake and the blood levels of ascorbic acid and vitamin A, and between the dietary protein and iron and the blood hemoglobin levels. Also found were some skin and eye changes, such as inflammation of the eyes and reddened gums, associated with low vitamin A and C levels of the blood.

The National Nutrition Survey in its first phase was directed to areas of low income in 10 states.[6] It uncovered an alarming amount of malnutrition that included every type of deficiency seen in underdeveloped countries. Although the number of cases of severe deficiency was few, one might well ask why kwashiorkor, rickets, goiter, and other preventable deficiencies should occur. The incidence of failure to gain at a satisfactory rate was high among preschool children. Anemia was highly prevalent in preschool children and in teen-agers, and dental decay was found to be practically universal. In many of the children unacceptable blood levels of ascorbic acid, vitamin A, riboflavin, protein, and thiamine were found.

Failure to maintain normal weight is a frequently recurring problem. The co-operative studies indicated that overweight and underweight occurred with equal frequency in boys and girls prior to adolescence. During adolescence, girls were more often overweight and boys were more frequently underweight, the degree of overweight or thinness increasing with age. Studies on overweight girls have shown that the caloric intake, surprisingly, is not as great as that of girls of normal weight; however the activity of the overweight girls has been less.[7,8]

Stresses of various kinds may have an adverse effect on nutrition. The incidence of tuberculosis is higher than it should be in the adolescent years and in early adulthood and is believed to occur more frequently in those who have had inadequate diets, especially with respect to protein and calcium. A large proportion of infants are born to young women who have not yet completed their own body growth and maturation. The stress of pregnancy can have serious effects on the girl who has had a poor intake of protein, calcium, and iron during the preceding years. Johnston[9] has called attention to the frequency with which slipping of the upper femoral epiphysis takes place in rapidly growing adolescent girls.

Common Dietary Errors

Studies of food habits of children have shown repeatedly that the foods requiring particular emphasis for the improvement of diets are milk, dark-green leafy and deep-yellow vegetables, and ascorbic-acid-rich fruits. Among the food habits that contribute to these deficiencies are these :

Poor breakfast or none at all: lack of appetite; getting up too late; no one to prepare breakfast; monotony of breakfast foods; no protein at breakfast, meaning that the distribution of good quality protein is poor even though the day's total may be satisfactory; too little fruit, meaning that ascorbic acid often is not obtained.

Poor lunches: failure to participate in school lunch programme; poor box lunches; spending lunch money for snacks or other items; unsatisfactory management of school lunch programme with resultant poor menus, poor food preparation, excessive plate waste.

Snacks: account for as much as ¼ of calories without providing significant amounts of protein, minerals, and vitamins; often eaten too near to mealtime thus spoiling the appetite.

Overuse of milk, especially by younger children: other foods are not eaten so that the intake of iron and certain vitamins may be low.

Self-imposed dieting, especially by teen-age girls: caloric restriction but no consideration given to protein, minerals, and vitamins.

Irregular eating habits : few meals with the family group; no adult supervision in eating; children often prepare own meals without guidance.

NUTRITIONAL REQUIREMENTS

Changes in Growth and Development

Height and weight changes follow a general pattern throughout childhood, but the chronologic age at which these changes occur may vary considerably; hence, a child cannot be compared with others of the same age. By the end of the first year the rate of growth has slowed considerably. The toddler gains 8 to 10 pounds during the second year, thus quadrupling his birth weight.

Thereafter, the yearly gains are approximately 4 to 7 pounds up to the preadolescent period.

For a year to two before adolescence and during adolescence the growth rate accelerates. The most rapid changes occur in girls between 11 and 14 years and in boys between 13 and 16 years. The rapid spurt in growth usually covers a period of two to three years. There are tremendous variations in the age at which maturation occurs so that the nutritional requirements for an 11-year-old girl who is maturing early, for example, will be quite different from those of the 11-year-old girl who has not yet begun to show these rapid changes.

The number, size, and composition of the bones change from birth to maturity. The skeleton has reached its full size in girls by the age of 17 years, and in boys at 20 years. The water content of the bones gradually diminishes as the mineralization increases. Provided that the diet remains good, bone mineralization continues for several years after the attainment of full size.

Dietary Allowances

Because the anabolic activities are considerable during the entire period of childhood, the nutritional requirements in proportion to body size and much higher than they will be in the adult years. Moreover, childhood and adolescence are times of considerable physical activity and hence the energy requirement is greater. The Recommended Dietary Allowances are those levels of nutrients that are believed to support optimum growth and development. When using these allowances it is important to interpret them in terms of the child's size as well as with reference to age category.

Energy: The very young child has a high basal metabolic rate incident to intensive cellular activity and to a proportionately high surface area. Year by year the rate of metabolism decreases, then accelerates somewhat during adolescence, after which it again declines to the adult level. The basal metabolism of boys is higher than that of girls owing to the greater muscle mass.

The one- to three-year-old needs about 1300 calories daily; the seven- to ten-year-old should have 2400 calories, which is more than his mother is likely to need; and the 15- to 18-year-old boy requires 3000 calories. Boys engaged in competitive athletics or

heavy labour must have considerably more calories if they are to grow satisfactorily. Macy and Hunscher[10] have shown that a deficit of as little as 10 calories per kilogram body weight resulted in failure to grow and depression of nitrogen retention even though the protein intake had been satisfactory.

Protein: The protein allowance for children at one to three years is 23 gm and increases to 36 gm for the 7- to 10-year-old. The allowance for teen-agers is approximately that of adult males and females. Based on body weight, the allowance decelerates from 1.8 gm per kilogram for the one- to three-year-old to 0.9 gm per kilogram for the teen-ager. About 12 to 15 per cent of the total calories should normally be obtained from protein.

Since the requirement for the essential amino acids is proportionately higher for children than for adults, one-half to two-thirds of the protein should be selected from complete protein foods.

Minerals: The recommended calcium and phosphorus allowances are 800 mg for children from one to ten years. During the ten years the allowance for boys and girls is 1200 mg. The greatest retention of calcium and phosphorus precedes the period of rapid growth by two years or more, and liberal intakes of these minerals before the age of 10 are a distinct advantage.[11] Children whose diets have been poor require a good diet for as long as six months before they can equal the calcium and phosphorus retention of children on a good diet.[12] Such a lag in retention can be a special hazard for the poorly nourished teen-age girl who becomes pregnant.

Adequacy of calcium intake is directly correlated with the intake of milk or milk foods. All non-milk foods can be expected to yield only 0.2 gm calcium in the diet of young children, and 0.3 gm calcium in the diet of older children.

The data on magnesium requirements are limited, and hence the daily allowances are estimates based upon amounts of magnesium contained in milk.[13] For children the allowances range from 150 mg at one to three years to 250 mg at 7 to 10 years. Boys from 11 to 18 years should receive daily allowances of 350 to 400 mg and girls should receive 300 mg. One quart of milk furnishes about 120 mg magnesium, and dark-green leafy vegetables are also good sources. Many diets that are reasonably adequate in

other nutrients may be somewhat lower than these allowances in magnesium; however, symptoms of magnesium deficiency have not been demonstrated on such intakes.

The recommended allowances of iron—from 10 to 18 mg, depending upon age—can be satisfied only when consistent emphasis is placed upon the inclusion of enriched or whole-grain cereals and breads, eggs, meats of all kinds, legumes, fruits, and green leafy vegetables. Far too often children of all ages consume minimum amounts of fruits and vegetables, thus leading to suboptimal iron intakes. Milk, which is low in iron, may be consumed in excessive amounts by some children, thus crowding out other essential foods.

Throughout childhood, but especially, during adolescence, the use of iodized salt should be encouraged because the high-energy metabolism increases the activity of the tyroid gland and the corresponding likelihood of simple goiter.

Vitamins: The vitamin requirements of children have not been extensively studied. Throughout childhood and adolescence 400 I.U. vitamin D should be provided—an allowance easily met by using fortified milk. The vitamin A needs are related to body weight, and the allowance increases from 2000 I.U. at one to three years to 5000 I.U. for boys and 4000 I.U. for girls. Milk, butter and margarine, egg yolk, dark-green leafy, and deep-yellow vegetables and fruits are good sources.

The allowances for ascorbic acid range from 40 mg for the one- to three-year-old to 45 mg for the 11- to 18-year-old boy and girl. Thiamine and niacin allowances are 0.5 mg and 6.6 mg, respectively, per 1000 calories. Allowances for riboflavin range from 0.8 to 1.2 mg for children from 1 to 10 years; teen-age boys need up to 1.8 mg and girls 1.4 mg. The allowance for vitamin B_6 ranges from 0.6 mg for the toddler 1.2 mg by 10 years of age. Teen-age boys and girls need 1.6 to 2.0 mg vitamin B_6.

Although allowances have been established for vitamin E, the data pertaining to requirements for children are limited. An increased intake of polyunsaturated fats increases the need for vitamin E. When diets are adequate in protein, minerals, ascorbic acid, and thiamine, the dietary allowances for folacin, vitamin B_{12}, and vitamin B_6 are likely to be met.

DIET FOR THE PRESCHOOL CHILD

Food Selection Correlated with Behavioural Changes

The nutritional requirements of the child cannot be satisfied apart from an understanding of behavioural changes which occur. During the second year the appetite tapers off corresponding to the slower rate of growth. Beal[14] found that healthy, well-nourished girls reduced their milk intake as early as six months and returned to higher intakes at two to three years of age. Boys also reduced their milk intake at about nine months, but started to increase their consumption between one and two years. An intake of 2 cups or less is not uncommon for a period of time. Some children's appetites improve by five years or earlier, but other children have poor appetites well into the school years.

Many mothers must be reassured that the child will remain well nourished provided that foods abundant in protein, minerals, and vitamins are offered, and that feeding does not become an issue between mother and child. Some compensation for the reduced consumption of milk may be made by incorporating milk into food such as simple puddings. The occasional use of flavourings such as molasses, cocoa, or the use of vegetable colours may introduce additional interest. Children may sometimes be encouraged to drink milk if they are permitted to pour the milk into a small glass or cup from a small pitcher. Cottage cheese and mild American cheese are often well liked and help to increase the calcium and protein intake.

Preschool children prefer mildly flavoured foods to those of strong flavour, or those which are spicy. Vegetables as a class of foods are frequently disliked. Most young children enjoy raw vegetables but they are unlikely to consume sufficient amounts because they become fatigued with chewing. Plain foods are generally well liked, but mixtures such as casserole dishes, creamed foods, and stews are not popular.

Fruits are well liked and may be given raw or cooked, although melons and berries should be used with discretion if at all. Simple desserts such as milk puddings, sherbets, ice cream, plain cakes, and cookies may be included.

The ability of the child to chew should determine the texture of foods he may be given. The toddler may be given chopped

vegetables and ground meat, whereas the three- to five-year-old can manage diced vegetables and minced or bite-size pieces of tender meat. Children enjoy chewing some foods such as zwieback, crackers, and strips or wedges of vegetables. Foods that are stringy such as celery, sticky such as some mashed potatoes, or slippery such as custard are often disliked because the child is not familiar with the texture.[15]

The gastrointestinal tract of the preschool child is easily irritated by very sweet or rich foods, fried foods, excessive amounts of cellulose, or foods inadequately chewed such as nuts. Foods of this nature may also displace dietary essentials and it is advisable to omit them in the diet of one- to three-year-olds, and to use them seldom for older preschool children.

Food jags are not uncommon, especially between the ages of two and four years. The child may shun all but a few foods, such as milk or peanut butter and jelly sandwiches. Such occurrences do not last too long, if the parent does not show concern, and if the foods which constitute the child's preference at the moment are nutritious in general.

The preschool child is almost constantly active. His interest is readily diverted from food. If he becomes overtired or excessively hungry, his appetite may lag a great deal.

Meal patterns: The Four Food Groups constitute a sound basis for planning the daily meals. Children of this age should consume each day:

2 cups milk

1 egg

1-3 ounces chopped meat, fish, or poultry

4 ounces orange juice or other source of ascorbic acid

2-4 tablespoons other fruit such as banana, peaches, pears, apple, apricot, prunes

2-4 tablespoons vegetables, including deep yellow and dark green leafy

1 potato

1 raw vegetable such as carrot sticks, cabbage slices, lettuce, tomato

1/3 to 2/3 cup enriched dry or cooked cereal

1-3 slices enriched or whole-grain bread

400 I.U. vitamin D, either as fortified milk or as a concentrate

The following meal patterns for a child from one to six* show that little adjustment needs to be made from the adult menu.

Breakfast

Fruit or juice

Cereal with milk

Toast

Butter or margarine

Milk

Lunch or Supper

Main dish—mainly meat, eggs, fish, poultry, dried beans or peas, cheese, peanut butter

Vegetable or salad

Bread

Butter or margarine

Dessert or fruit

Milk

Dinner

Meat, poultry, or fish

Vegetable

Relish or salad

Bread

Butter or margarine

Fruit or pudding

Milk

Snacks: Most young children with a limited capacity for food are more likely to obtain all the dietary essentials if they are fed something in the middle of the morning and the afternoon. Moreover, very active children become excessively fatigued and hungry if they are not fed between meals. Snacks should make a

* *Your Child from 1 to 6.* Children's Bureau Pub. 30, Welfare Administration, U.S. Department of Health, Education, and Welfare, Washington, D.C., 1963.

liberal contribution to one or more of the nutrient needs. Some which are suitable for preschool children are:

Fruit juices with little or no sugar

Milk and milk beverages

Fruit of any kind; raw vegetables

Small sandwiches; crackers with peanut butter

Molasses, oatmeal, or peanut butter cookies

Dry cereal from the box or with milk

Cheese wedge

Fruit sherbet or ice cream

Establishing Good Food Habits

Suggestions have been made in the preceding chapter for the establishment of good food habits in the infant. In addition, the following considerations are conducive to the development of good food habits in the preschool child.

Meals should be served at regular hours in a pleasant environment. The child should be comfortably seated at a table. Deep dishes permit the child to get his food onto the fork or spoon with greater ease. A fork, such as a salad fork with blunt tines, and a small spoon can be handled comfortably. A small cup or glass should be only partially filled with liquid to minimize spilling; however, the co-ordination of eye, hand, and mouth is difficult and some spilling is to be expected.

Children enjoy colourful meals just as adults do. Their appetites also vary from day to day, and like adults they react strongly to portions that are too large. It is much better to serve less than the child is likely to eat and to let him ask for more.

Even favourite foods should not be served too often. Breakfasts do not need to be stereotyped. A hamburger or sandwich with an orange cut in sections to be picked up with the fingers is just as satisfactory as a juice, cereal, and egg breakfast.

Fewer difficulties are likely to be encountered if new foods are given at the beginning of the meal when the child is hungry. A food is more likely to be accepted if it is given in a form which can be easily handled, which can be chewed, and if some favourite food is also included in the same meal. The parent should assume that

the child will also take some responsibility in accepting the offered food.

Whether or not the preschool child should eat with other members of the family or alone is a matter that each mother must determine for the child's greatest good and the family's convenience. If the father returns from work at such an hour that the evening meal must be late, if the child becomes overexcited about the family doings, or if the child is expected to live up to a code of behaviour beyond his young years, it is better that he be allowed to eat before the rest of the family in a pleasant, quiet atmosphere with his mother nearby. Even so, an occasional meal with the family may be a treat for the child and parent if tension can be avoided. Since children are great imitators, they enjoy doing just as Daddy or Mother or the other children are doing.

The child may well learn early in life that he is expected to eat foods prepared for him, but this does not mean that nagging or bribery will accomplish anything. Children, like adults, enjoy attention, and they are quick to realize that food can be powerful weapon for gaining such attention. It is therefore important to recognize that a display of concern or the use of force in getting a child to drink milk or to take any other food can have nothing but unfavourable effects. When a child refuses to take a food, the unwanted item should be calmly removed without comment after a reasonable period of time. If the child is refusing to eat because he thereby attracts attention, the mother should make certain that the child receives his full share of affection and companionship at other than mealtimes. By so doing the child will lose interest in using food as a weapon.

DIET FOR THE SCHOOLCHILD

Characteristics of Food Acceptance

Elementary-school children are usually better fed than preschool children or adolescents. Group acceptance is extremely important at this time, and the child needs to be able to keep upto with his classmates and to have a sense of accomplishment. When the child goes to school for the first time he makes acquaintance with food patterns that may be different from those he knows at home. He learns that certain foods may be acceptable to the peer group, whereas other foods from a different cultural pattern may

be looked upon with disdain; as a result he may be unwilling to accept these foods at home—good though they may be. On the other hand, within a group he is willing to try foods with which he is unacquainted and which he would not try alone.

Schoolchildren have relatively few dislikes for food except possibly for vegetables, which are usually not eaten in satisfactory amounts. By the time children reach 8 to 10 years of age the appetite is usually very good. Feeding problems are more likely to result because parents are unduly concerned with behaviour at mealtime which does not come up to adult standards. Most children of this age are in a hurry, and don't like to take time for meals. Breakfast, especially, is likely to be skipped.

Schoolchildren may be subject to many stresses which affect the appetite. Communicable diseases occur often in this age group. They reduce the appetite on the one hand, but they increase body needs on the other. Schoolwork, class competition, and emotional stresses in getting along with many children may have adverse effects on appetite, as may also an unbalanced programme of activity and rest.

Choice of Foods

Table 7.1 lists the kind and amounts of food which may be taken in a day by healthy schoolchildren. A number of other

Table 7.1

Foods to Meet Nutritional Needs of Elementary-School Children

Food	*6 to 10 years*	*10 to 12 years*	*12 to 16 years*
1	*2*	*3*	*4*
Milk	2-3 cups	3-4 cups	4 cups or more
Eggs	1	1	1 or more
Meat, poultry, fish	2-3 ounces (small serving)	3-4 ounces (average serving)	4 ounces or more (large serving)
Dried beans, peas, or peanut butter	2 servings each week. If used as an alternate for meat, allow ½ cup cooked beans or peas or 2 tablespoons peanut butter for 1 ounce meat		
Potatoes, white or sweet (occasionally spaghetti, macaroni, rice, noodles, etc.)	1 small or 1/3 cup	1 medium or ½ cup	1 large or 3/4 cup

(Contd.)

1	2	3	4
Other cooked vegetable (green leafy or deep yellow 3 to 4 times a week)	1/4 cup	1/3 cup	1/2 cup or more
Raw vegetable (salad greens, cabbage, celery, carrots, etc.)	1/4 cup	1/3 cup	1/2 cup
Vitamin C food (citrus fruit, tomato, cantaloupe, etc.)	1 medium orange or equivalent	1 medium orange or equivalent	1 large orange or equivalent
Other fruit	1 portion or more, as 1 apple, 1 banana, 1 peach, 1 pear, ½ cup cooked fruit		
Bread, enriched or whole grain	3 slices or more	3 slices or more	4-6 slices or more
Cereal, enriched or whole	½ cup	¾ cup	1 cup or more
Butter or fortified margarine	1 tablespoon or more	1 tablespoon or more	1 tablespoon or more
Vitamin D	400 I.U. at all ages, using: fortified milk, fish-liver oil, or vitamin D concentrate		
Additional foods	Sweets, desserts, etc., to satisfy energy needs		

equally satisfactory patterns could be devised for different cultural groups. A diet for adults which places emphasis first on the inclusion of protein, minerals, and vitamins is also a good one for schoolchildren. The amount of milk given to children should be greater than that for the adult. Although no foods need to be forbidden to this age group, it is extremely important that high-carbohydrate and high-fat foods not be allowed to replace essential items of the diet.

Food Habits

The suggestions concerning good food habits for preschool children also apply to schoolchildren. A good school lunch programme may introduce new foods in a setting where the child is anxious to conform to the group. The elementary teacher may integrate nutrition education with the total classroom experience so that good food habits are strengthened.

Since children are likely to be in a hurry, it is often wise to require that a certain time be spent at the table—say 15 or 20 minutes—so that the child will take time to eat. Children learn

good manners by imitation of adults, and not by continuous correction at the table. During the elementary-school years, little can be gained by overemphasis on manners. In fact, the food intake may be adversely affected.

DIET FOR THE TEEN-AGER

Characteristics of Food Intake

Even boys and girls who have had an excellent dietary pattern are likely to succumb to bizarre, unbalanced diets during the adolescent years. Teen-agers have many concerns about their development such as the size and shape of the body, their attractiveness, skin conditions, their vitality, sexual development, and social approval by their peers. They feel independent and seek freedom to make their own decisions. It is a period in which family conflict is likely to increase.

Most teen-agers are concerned about their body weight.[16, 17] Most girls want to weigh less and equate overweight with fatness which is undesirable. Generally, they want smaller hips, smaller thighs, and smaller waists but larger busts. Most boys want to weigh more and they equate overweight with muscle development which is desirable. They want a larger upper torso and arms, an indication of strength.

Teen-agers are often fatigued, anxious, and under emotional stress. These factors may have an adverse effect on the retention of nutrients. Students who were taking examinations and young women who were upset about a pregnancy were found to have negative nitrogen and mineral balances.[12, 18] Emotional difficulties may stem from the feeling of social inadequacy or the pressures of schoolwork. When there is conflict within the home because of the teen-ager's food choices, failure to accept responsibilities, the use of money, dating hours, and so on, the emotions not only determine food intake for some adolescents but also modify the nutrient utilization.

Selection of Foods

Milk, green leafy and deep-yellow vegetables, and citrus fruits are the foods which especially require emphasis. Moderate amounts of sweets, soft drinks, coffee, and tea cannot be considered harmful for this age group, provided that they do not replace essential

foods in the diet. The list in Table 7.1 should serve as the starting point for the planning of meals at home and in the school lunch.

Snacks may be counted upon as supplying one-fourth, or more, of the caloric requirement. They should also furnish an equivalent amount of the day's allowances for protein, minerals, and vitamins. Thus, sandwiches, hamburgers, fruit, and milk should be encouraged. Candy, rich pastries, cookies, and pretzels may be satisfying to the palate, but will not support their caloric content with important nutrients.

A study has shown that snack pattern may, in fact, be preferable to three meals a day, provided that the choice of snacks is good. In three boarding schools 226 boys and girls aged 6 to 16 years were fed for one year on one of three plans of meal frequency: in school A, three meals daily; in school B, seven meals daily; and in school C, five meals daily.[19] The average calorie intakes and food allowances did not differ significantly, but individual records were not kept. The older children, 11 to 16 years, who received only three meals per day showed increased tendency to deposit fat as demonstrated by the increase in the weight-to-height proportion and by caliper measurements of skinfold thickness. The differences were more marked in the girls than in the boys. These differences were not observed in the younger children.

Food Habits

Good health in general is too abstract an approach to interest the teen-ager. Most of them have never known anything but good health. Girls can be appealed to on the basis of a better figure, an improved complexion, and glossy hair. Boys are especially interested in physical fitness and the greater ability to compete in athletic contests. They, too, are concerned about complexion problems. Adolescents are more anxious to improve their eating habits when they are reminded that their acceptance of foods makes them a more appreciated dinner guest.

Boys and girls give a surprisingly good performance when given responsibilities concerning meals at home. When they share in the planning of menus, in the purchase of foods, and in the preparation of meals, they take pride in showing their skills in shopping, or in trying a new recipe. Of course, it is good psychology to share these responsibilities as a privilege of growing up and not

as a burden imposed by the parent. In their fulfilment, with subtle guidance and praise where merited, food habits are often improved.

CHILD NUTRITION PROGRAMMES

In 1853 the Children's Aid Society of New York opened a vocational school for the poor and served meals to those who attended. School feeding was initiated in some elementary schools in Philadelphia in 1894. After the turn of the century many schools throughout the country provided meals or hot-dish supplements to carried meals.

The school lunch programme has experienced rapid growth since the 1930's when surplus commodities were first distributed following the passage of a law in 1935. Although more than a third of all elementary- and secondary-school pupils receive plate lunches on any given school day, many of the most needy children do not have the programme available to them. The existence of malnutrition in the United States was highlighted in the late 1960's, and as a result a considerable expansion of child nutrition programmes supported by the U.S. Department of Agriculture has taken place.[20]

National School Lunch Programme

In 1946 the National School Lunch Act was passed to provide participating schools with (1) cash assistance; (2) donation of surplus food commodities; and (3) technical assistance in the purchase and use of foods and in the management and equipment of the school lunchroom. More recently, legislation has authorized higher-than-average rates of reimbursement for schools that have a large attendance from low-income areas. Financial assistance is also provided to help schools in these areas to purchase equipment needed for the lunch programmes.

To participate in the programme, a school must agree to: operate the programme on a non-profit basis; provide free or reduced-price lunches for needy children; serve all children regardless of race, colour, or national origin; serve nutritious lunches that meet the requirement for type A lunches as established by the Secretary of Agriculture; provide kitchen and dining facilities. No discrimination must be shown in any way to children who are eligible for free or reduced-price meals; that is , they must not be identified by placing them in separate lines, requiring them to sit

in places set apart, or requiring them to provide service as a reimbursement for the meal.

Type A lunch: Five components are included in the Type A lunch:

1. Fluid whole milk, 1/2 pint, served as a beverage.

2. Protein-rich food such as: 2 ounces cooked or canned lean meat, fish, poultry; 2 ounces cheese; 1 egg; 1/2 cup cooked dry beans or peas; 4 tablespoons peanut butter; or an equivalent of any combination of these in a main dish.

3. Vegetables and fruits, at least 3/4 cup, consisting of two or more servings. One serving of full strength juice may be counted as not more than 1/4 cup of the requirement.

4. Whole-grain or enriched bread, 1 slice; or muffins, cornbread, biscuits, rolls made of enriched or whole-grain flour.

5. Butter or fortified margarine, 2 teaspoons, as a spread, as a seasoning, or in food preparation.

Nutritive Value of Type A Lunch

When foods are served in the amounts specified, and additions are made to satisfy the appetite, the type A lunch provides, on the average, one-third of the recommended allowances for the 10- to 12-year-old child. Larger portions must be provided for older children. Since the child eats but five meals in the school each week, the contribution represents about one-fourth of his total nutritive needs.

Some care must be taken in the selection of fruits and vegetables. A vitamin-C-rich food should be served daily, and a vitamin-A-rich food at least twice a week. Well managed school lunch programmes seldom permit sales of soft drinks, candy, pretzels, and similar carbohydrate-rich foods because they contribute little except calories to the child's nutritional needs, and because the child's money may be used for these empty calories rather than the more nutritious foods. The American Medical Association, the American Dietetic Association, and the National Congress of Parents and Teachers have opposed the sale of candy and soft drinks within the schools.[21, 22]

School Breakfast Programme

Presently, the breakfast programme is limited to schools that

have a large number of needy children. Under the U.S. Department of Agriculture Programme funds are provided to help schools pay for the foods purchased for the preparation of the breakfast, food commodities are donated, and financial assistance is provided in the purchase of kitchen equipment. The standard setup for the breakfast is:

1. One-half pint whole milk.

2. One-half cup fruit, or fruit or vegetable juice.

3. One serving bread or cereal; may be 1 slice whole-grain or enriched bread, or an equivalent amount of cornbread, biscuits, or muffins; or 3/4 cup of whole-grain or enriched or fortified cereal.

4. As often as practicable, a serving of protein-rich food such as 1 egg, or 1 ounce meat, fish, or poultry, or 1 ounce cheese, or 2 tablespoons peanut butter.

Additional foods to round out the breakfast and to satisfy the appetite would include foods of popular appeal such as doughnuts, potatoes, or bacon; sweeteners; butter or margarine.

The standards for participation in the Programme are similar to those for the National School Lunch Programme.

Special Food Service Programme

This programme provides assistance to day-care centres, recreation centres, settlement houses, and summer day camps. It helps to improve the nutrition of preschool as well as school-age children. This programme provides cash assistance up to a maximum of 15 cents for breakfast, 30 cents for each lunch or supper, and 10 cents for each supplemental feeding between meals; finances up to 80 per cent of operating costs in cases of severe need; supplies donated foods; furnishes financial assistance of purchase or rent for necessary equipment; and provides technical assistance in setting up the programme. The requirements for participation include meals served according to U.S. Department of Agriculture standards, operation for the programme on a non-profit basis for all children without discrimination, and free or reduced-price meals to needy children.

Special Milk Programme

This provides reimbursement to schools, child-care centres,

and camps for part of the cost of the milk served. Because the milk can be sold at low cost to the child, milk drinking is encouraged. In schools where there are many needy children the full cost of the milk served to these children is reimbursed.

Mother's Milk is Nature's Gift to Infants

* Start breast feeding within one hour of birth in normal deliveries and within 4-6 hrs., in C-Section deliveries.
* Early initiation of breast feeding provides enough *'colostrum'* (first milk) to the child and establishes good lactation.
* Pre-lacteal feeds are not necessary and can be harmful.
* No water, ghutti, fresh animal milk, instant formula or other liquids should be given before the age of 4 months. These and bottle feeding increase the risk of infections and reduce the secretion of breast milk.
* Breast feeding should be continued when the child is ill. An ill mother should also continue to breastfeed as her milk is safe for the baby.
* At 5-6 months, introduce home cooked semi-solid foods (not the liquids) and continue breast feeding well upto 2 years.

Complementary Feeding

* Start complementary feeding at 5-6 months with a cereal porridge made from atta, suji, ground rice or millet using water or milk and a small quantity of oil or ghee and sugar/jaggery. Feed 1-2 spoons once or twice a day and gradually increase the quantity and frequency.
* Seasonal fruits like banana, papaya, chikoo or mango should be mashed and fed at least once a day.
* Feed modified family food when the child is 6-9 months old like mashed rice with dal and mashed vegetables (without spices), or roti softened in dal or milk, or mixed foods like khichri, idli soaked in unspiced sambhar etc.
* Green leafy vegetables should be added to dal, khichri, dalia etc., to increase the nutritive value.
* Carrots and pumpkin can be fed to the infants by grating

and cooking with sugar/jaggery.

* One to two teaspoons of oil or ghee should always be added to the child's food to increase the energy density.
* Give a variety of home foods including vegetables and seasonal fruits to a 9-12 months old child. A soft boiled egg, fish or minced meat can be introduced in non-vegetarian families.
* Roast any cereal/millet and a pulse in the ratio of 3:1, grind and store in air-tight containers to serve as instant food for the child.
* Reconstitute using boiled water or milk and feed after adding sugar and oil/ghee, to the child.
* Small babies need to be fed 5-6 times a day in addition to breast-feeding.
* A child of 1-2 years should share the family diet and requires half the amount of food that his mother eats.
* Continue feeding during illness and give additional feeds after illness to regain health.

Prevention of Infections

* Wash hands thoroughly with soap and water after cleaning the stools of the child and using the toilet.
* Wash hands thoroughly before preparing food and feeding children.
* Protect the child's food from dust and flies by keeping it covered.
* Use only safe drinking water stored hygienically.
* Inculcate personal hygiene in children by giving regular bath, cleaning teeth, cutting nails and toilet practices. Keep the house clean.
* Give all the immunisation in time to protect children from diseases.
* Keep medicines, kerosene, pesticides etc., out of reach of children to prevent accidents.
* Provide encouragement for playing exploration, talking and learning to enable optimum development of child.

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8

Beyond Economics and Nutrition : Approach to Food Policy

Governmental nutrition policy, given appropriate conditions for the feasibility of its development, is determined by the body politic. Inasmuch as nutrition is usually recognized to be, at least in part, a technical area, scientists (health specialists, nutritionists, and economists) are generally called upon to advise legislators, cabinet ministers, and planners in the formulation and implementation of policy.

Let us at the outset recognize that scientists have had a considerable favourable influence in the past 50 years, not only in their purely technical roles (for example, quantitative definition of nutritional requirements) but also in an ethical framework (such as implicit recognition that all human beings must be fed a similarly adequate diet). This article, however, is not concerned with past achievements but with trying to examine the factors that are hampering the development of practical and acceptable policies in the fields of foods and nutrition. In particular, we shall analyze the disciplinary limitations that prevent physicians, nutritionists, and economists from working together with governments to present coherent, broad-based plans in these fields.

Object of a Nutrition Policy

We shall assume in this article that the government has decided that adequate nutrition for all the people is an appropriate national goal, as an alternative to the traditional practice of letting

nutrition status be secondary to agricultural policy, foreign trade, health policy, social policy, and economic conditions. This being accepted, there are a great many different possible means, some direct and some indirect, for bringing about positive nutritional effects. A number of such means are listed in Table 8.1.

Consideration of this table shows that means of influencing the state of nutrition are extremely varied. This observation, evident to the non-specialist, is often lost sight of by nutritionists, physicians, and economists, each of whom tend to consider only those means which can be activated exclusively within the confines of their own disciplines. Thus, physicians will usually be concerned solely with medical intervention—whether preventive, curative, or rehabilitative—dealing with deficiency diseases, nutrition-related infections, and degenerative diseases. Nutritionists will be concerned with supplementary feeding, nutrition education, food advertising, and labelling. Economists, if they are at all concerned with levels of food consumption, will consider measures having to do with production, imports, and income policies. The consumer is perforce broader in his interest and will be aware, however inchoately, of a multiplicity of factors impinging on his nutritional well-being.

Inadequacies of Present Models : Rationing Model

While nutrition scientists may be uniquely qualified to define nutritional targets and goals, they sometimes are strangely unsophisticated in discussing the means to be used in reaching these objectives. Their models seem almost uniformly to be based on considerations that are applicable only under conditions of total war and are carried out by a well-informed government, a large and well-organized bureaucracy, and a highly disciplined population (such as in Britain in World War II). Under such conditions food supplies are tailored to physiological requirements for nutrients by strict rationing systems. The social conditions are adjusted so that everyone can obtain the foods covering the requirements ascribed to his or her classification (sex, age, reproductive status and intensity of physical labour). In turn, the national procurement policy is conducted so as to cover the collective national nutrient requirements. At most, adjustments are made from time to time to replace certain sources of calories and nutrients by equivalent amounts of appropriate alternative

foodstuffs. That such systems, based on the calculations of nutritionists, worked as well as they did in the United Kingdom and in Switzerland during World War II is a tribute to the scientists, the governments, and the populations of these two countries. A less elaborate system worked reasonably well in the United States at the same period. However great these achievements, similar rationing schemes do not represent satisfactory models for peacetime food and nutrition policies in countries, whether wealthy or poor, that do not have simultaneously the scientific resources, the organized bureaucracy, and the coercive governments necessary to carry out nationwide, prolonged rationing schemes. Total control of production, distribution, and information is needed for such programmes to be successful, and there is a question as to whether, even under such conditions, rationing can go on indefinitely. Awareness of the inevitable inequalities and inefficiencies eventually destroys the best-planned directive measures for food control. While consumers may be willing to undergo inconvenience and deprivation during wars and revolutionary periods, they are usually loath to do so indefinitely. It is a misconception to believe, incidentally, that the centrally planned economies of Eastern Europe and Asia have succeeded in implementing non-demand nutrition policies while the capitalist countries have lagged behind. While centrally planned economies do have food production and income policies, they do not usually have integrated nutrition policies as such, and many of their purported nutrition policies are not necessarily appropriate or successful. It is a gross over-simplification to believe that a centrally planned socialist economy means that problems of demand have been eliminated and that supply is automatically adjusted "to each according to his needs."

The prerequisites for highly centralized direction of all aspects of the food supply do not exist at present in most countries. Thus, models for intervention other than adjusting supplies and distribution directly to requirements must be sought.

Controlled Demand, Non-income Models

While most nutritionists are resigned to the idea that they cannot, under normal conditions, control supplies, they often strive for a utopia in which they control demand. Their ideal is a development of popular nutritional awareness so total that price, income, and taste can be eliminated as factors of practical

importance in determining demand. They often forget the primacy of economics in influencing patterns of consumption and concentrate almost exclusively on the duel (indeed, the crusade) of education against advertising, which, in their view, represents the decisive factor in determining what people will eat. For many nutritionists, this viewpoint leads directly to a yearning for a directive banning all food advertising. In their view, the elimination of this enemy would lead in due time to the provision of a balanced diet for all consumers. Unfortunately, while there is abundant evidence that demand can be modified to a degree by limiting or eliminating unjustified claims or misinformation on food advertising, as well as by consumer information and health and nutrition education, there is also overwhelming evidence that such economic factors as price and income have at least equal importance, if not much greater influence. To focus exclusively on the cognitive aspects of food choices to the exclusion of economic means of intervention is to limit drastically the possibilities of implementing a nutrition policy.

Ignoring actions that modify supply as well as demand is to be equally myopic and self-limiting. Whether the middleman, fast food service institutions, food processing, "factory farming," agribusiness, and the entire food distribution system are in any way villains, which some groups declare them to be, is of little significance. The fact is that every component of the food system can be acted upon to bring about improvements of the nutritional status of large numbers of people. Similarly, income policies are crucial to raising the nutritional levels of large numbers of people. The most successful nutrition education system and the total elimination of noxious advertising, however desirable, will not substitute for an income adequate to bring an inexpensive but nutritionally satisfactory diet conforming to national preferences. Unless all these factors are taken into account in the elaboration of a planning model, the development of a sound nutrition policy is seriously hampered.

Economic Models that are Not Health-Directed

Economists suffer from their own limitations. They are unwilling to pay much attention to those commodities that do not travel through channels of trade (in fact, most of the foodstuffs produced in subsistence farming areas) or to those

commodities—fruits, vegetables, and small amounts of home-grown animal products, human milk, eggs, rabbits, and the like—that make a considerable contribution to good nutrition but are difficult to quantify. They thus arrive at such statistics as calculating average incomes for entire populations as equivalent to, say, less than $ 50 a year, a conclusion that does not lend itself to any international nutrition comparisons. Another bias of economists is their preference for theoretically cost-efficient measures such as fortification with added nutrients, however impractical and inadequate these measures usually are in the developing countries that are supposed to benefit most from them. It sometimes seems that the economists' models, consisting as they do of quantifiable food tonnages that move or can move through channels of trade and of the products of industrialization, suggest an ideal diet made of a homogeneous mixture of the dominant regional cereal (preferably one variety), and one variety of soyabean, this mixture to be fed to humans or farm animals, to travel, or to be distilled depending on available systems and local incomes. If health problems are taken into consideration at all, they are often dealt with through suggestion of appropriate fortification with vitamins and amino acids. However convenient the oversimplified diet of economists may be for the purposes of international negotiations (the Rome World Food Conference dealt almost exclusively with cereals, with few mentions, at most, of soyabeans and sugar), it bears little resemblance to the diets that are examined by health and nutrition workers for nutritional adequacy. The two groups must come closer in their definition of "food" if adequate food and nutrition planning is to evolve.

Prerequisites for Joint Planning

We must emphasize that economists and planners appear unreceptive to qualitative statements, however well established. The statement that problems of malnutrition are severe and must be eradicated is unlikely to bring about changes in their economic plans. Their tools involve quantifiable variables, and unless the problems are presented to them in quantitative terms, they are unable to grapple seriously with them. Specifically, the information they require is the following: *(i)* the size and nature of the malnutrition problem, expressed in terms of the demographic

Table 8.1

Actions and Interventions that May Alter Nutritional Status

Category	*Action*
Need	Actions affecting health and biological utilization of food
	Supplying missing nutrients on either a prophylactic or curative basis
	Alterations of environmental sanitation that have indirect impact on health and biological utilization of foods
	Altering physiological requirements of persons by environmental manipulation
	Surveillance and treatment activities to assess special nutrient needs of the ill or otherwise handicapped
	Actions or events decreasing the numbers of persons at risk of malnutrition by various means
Supply	Altering production factors (land, labour, capital, technology) or inputs needed to raise food
	Changing type of foods produced or how they are used
	Altering processing and manufacturing of food products
	Altering marketing efficiency
	Foreign trade regulations modifying the food balance of a country
	Provision of food aid to the poor within the country or from abroad viz food distribution programmes which, in effect, transfer food or purchasing power specially for food from more affluent to more needy groups
	Enrichment or conservation of food in the home or at the point of consumption
Demand	Increasing income by raising gross national product, or distributing income to poverty groups so as to increase their purchasing power
	Government interventions to affect price structures and hence demand
	Government programmes to influence consumption
	Education
	Altering food habits and mores
	Favouring or promoting conservation of breast feeding and increasing its prevalence and duration.

and socio-economic characteristics and number of persons who are malnourished or at risk of malnutrition; *(ii)* short-term and long-term targets, again in quantitative terms; and *(iii)* yardsticks for measuring progress.

Before these data are furnished, little is likely to be done. At the same time (except for extreme emergencies, when cases of

starvation, edema, severe weight loss, or acute deficiencies can be counted with little margin for disagreement between experts), the data economists want are in the very areas where clinicians and nutritionists are most loath to come out with flat, numerical statements. Health professionals will agree that the definition of malnutrition—entailing, as it may, choices between clinical, anthropometric, biochemical, or dietary criteria—is uncertain and subjective; that the standards for all of these criteria are arbitrary; and that small variations in cutoff points will yield widely different prevalences of malnutrition. Faced with this confusion and lack of agreement on the part of health and nutrition experts, economists and planners are likely to ignore the problem of malnutrition or to go ahead on the basis of indirect but quantitative estimates, such as a "poverty line" based on income, or budget study data compared with the food purchases of "representative" families. In the United States, it was only in the 1970's that partial baseline data on malnutrition were obtained in the course of the Ten State Nutrition Survey. Even then, nutritionists were hard put to summarize clearly the results of this (partial) survey or to recommend targets for action and yardsticks for measurement of progress.

Nutrition scientists must be encouraged to formulate serviceable definitions of malnutrition that can serve as necessary bases for action. Definitions worked out by nutritionists, although not infallible, should come closer to the realities to health than do those worked out by economists, managers, and politicians. That the politicians have been willing in the past to attempt such definitions, unaided as they were by specialists, has been in many cases the prime impetus to development of socio-economic conditions leading to better nutrition.

Who are the Nutrition Experts?

Nutritionists have another complaint about economists and planners for which lack of communication between the two groups must again be blamed. They understandably object to the unfortunate tendency of economists to check with the wrong people when matters nutritional arise. In the absence of a permanent, constructive dialogue with nutritionists, the economist, when faced with claims that economic and agricultural conditions are leading to many people being ill, logically enough calls in a physician as adviser. Unless the economist is particularly well

counselled or lucky, he or she may, however, have the wrong adviser. The reasons for this are several.

First, deficiency diseases and diseases exacerbated by malnutrition are overwhelmingly diseases of the very poor, the class least likely to be seen routinely by physicians. When the poor finally receive medical treatment, usually very late in the natural history of the disease process, the nutritional factors in the etiology and pathogenesis of their health problems may be camouflaged by other, more dramatic medical conditions that have also gone untreated, and the underlying malnutrition may be disregarded.

Second, in developing countries and even in rich countries, the poor are least likely to be seen by the influential private physicians or senior academics among whom advisers to planners are likely to be recruited.

Third, throughout the world, and particularly in the United States, senior physicians are more likely to be enthused about dramatic methods of curative medicine than about the drabber, although ultimately more useful, preventive aspects of medicine, of which nutrition is the most important example.

Finally, even when physicians are conscious of the importance of nutrition as a discipline, they are almost invariably unable to translate "nutrition" into foods and their relation to habits and patterns of various socio-economic and ethnic groups or, for that matter, into the nuances of micro-economics and food distribution within the family. Thus, their opinion in feeding programmes, food assistance interventions (whether in the form of money, food stamps, or other distributive measure), nutrition education, consumer education, and so forth, are generally far less factually based and authoritative than their views on, say, the etiology and treatment of acute diseases. Unless the physician asked to serve as adviser on nutritional problems is well versed in epidemiology and public health nutrition and has some knowledge of food science and the sociology of nutrition, his advice may be useless or misdirected.

Nutrition, Socio-economic Analysis, and Advocacy

All too often, nutrition scientists seem unable to correlate their findings about the state of nutriture of individuals with socio-economic variables. This inability, coupled with overcaution in

analysis of economic determinants of consumption, means that advocacy is all too often left to consumer spokesmen with no real understanding of health priorities in human nutrition. The often exaggerated or inaccurate statements of such spokesmen, instead of prompting nutrition scientists to take over the advocacy role and put it on a firm factual and scientific basis, seems, on the contrary, to frighten them even farther away from such a role. As a result of this attitude (probably due to overdefenciveness about their colleagues' opinion), interventions necessary to correct nutritional inadequacies are not undertaken, and no systematic trials and evaluations are conducted to assess what the best method for attacking nutritional problems may be or what progress is being made. As an example, since the 1969 White House Conference on Food, Nutrition, and Health, federal expenditures on food programmes (food stamps, school lunch and breakfast programmes, summer food programmes, community meals and meals-on-wheels for the elderly and shut-ins, and special programmes for pregnant and nursing women and infants) have risen from $ 600 million to over $ 6 billion without adequate monitoring of their relative effectiveness. The surveillance of the state of nutrition of the nation, recommended by the conference has not been organized, and the American people have gone through a massive change in the nature of the food supply massive increases in the price of various foods, profound changes in welfare and social security legislation, a deep economic recession and an explosive increase in the size of government food programme without any serious effort being made to follow the consumption levels of the various groups in our population. Indeed, the decennial consumption survey conducted by the U.S. Department of Agriculture has been postponed by at least 1 year. The moribund state of nutrition as a tool in social engineering encourages its neglect by economists and the filling of the gaps by amateurs and extremists.

Nutrition and Public Education

A recent essay on science literacy distinguishes three distinct but related forms: practical, cultural, and civic. This framework can also be used to determine the objectives of nutrition science orientation needed by various members of society.

The most obvious need of laymen is for practical nutrition

advice given in ordinary language. Such knowledge can be co-ordinated with that given in formal educational settings. The bulk of the informational effort should be co-ordinated through the non-formal mass media. Nutrition scientists should be involved in the preparation of this message, but are they always qualified? Who are those nutritionists? Those falling under this umbrella term may include those having doctoral degrees in the biochemistry of nutrition, food science, or public health nutrition; physicians specializing in clinical nutrition; dietitians; home economists; food technologists; and educators with special expertise in food and nutrition. Unfortunately, the top of the pecking order belongs to the biochemists and clinicians, who, however deep their knowledge of intermediary metabolism or the treatment of acute conditions, are rarely prepared to dispense the necessary advice on menu planning, food buying, and food preparation. Their social concerns incline heavily toward support of research and academic institutions, and most of them have not bothered to inform themselves seriously about consumer problems. The situation is complicated by the fact that specialists are usually extremely timid at dispensing information about fields other than their own. Thus, a biochemical nutritionist will not be willing to publicly hazard an opinion on additives or food prices. For the general public, these are part of nutrition, and our expertise is classified as useless. The home economists are usually better prepared to give advice on a broader range of public concerns, but even they are usually afraid to venture in some fields, such as food toxicology or food assistance programmes, and their prestige is low as compared with physicians and scientists.

Cultural nutritional literacy must be instilled in as large a part of our population as possible if nutrition considerations are going to be incorporated in the culture and broad academic programmes. Nutritionists all too often fail there as well. Instead of making a serious effort at teaching the science of nutrition to the intelligent public, they have all too often insulted it by presenting it with quasi-scientific utterances about "good food habits", "balanced diets", or the "basic four", which tend to be vague, uninteresting, and, in the case of the last example, misleading. Fortunately, we are beginning to see some interesting and scholarly and at the same time readable approaches to nutrition as a cultural topic.

Our major concern here being with nutrition policy, it is the

element of civic nutrition education that is crucial for our purpose. The aim of imparting civic nutritional literacy is to enable professionals, both those specialized in nutrition and those whose actions affect nutrition to become more aware of the nutrition-related issues and to interpret those issues in policy-making. Such civic literacy involves some acquaintance with a broad range of issues, from agricultural policy to health to related social and economic issues. Civic literacy implies an interest in numerical, nationwide data on nutritional problems, an ability to evaluate advocacy, and to follow public actions likely to affect the nutritional well-being of large sections of the nation's population. In an increasingly interdependent world, civic literacy involves seeking information, forming quantitative opinions, and endorsing action on the international plane as well.

Misclassification of Nutrition Intervention

In the absence of qualitative baselines, yardsticks, and targets pegged to nutritional health, it is understandable that economists all too often neglect health as a major aim in considering policies affecting food and nutrition. However, they often also fail to realize that certain "nutrition" programmes may have objectives that far exceed the narrow nutritional goal that dominates their classification. For example, the nutritional benefits derived from such popular programmes as the community meals for the elderly or school lunch could be hard to justify on a cost-effectiveness basis: they both, at best, supply a fraction of the total number of meals consumed during a year; the same amount of money put, for example, into food stamps should guarantee more nutrition. On the other hand, if they are regarded as distributive measures with social welfare spin-off benefits, such as decreased isolation and increased opportunity for health surveillance and education of the elderly, socialization and nutrition education of children, and employment of neighbourhood mothers as school lunch aides, the yardsticks applicable become quite different. Even though both the lay public and most nutritionists look at them as food and nutrition programmes, the fact is that nutrition is not the only or even the main aim of these activities.

On the other hand, programmes that are not thought of as nutrition programmes by either nutritionists or economists may have a great deal to do with nutrition. These include actions that

affect income and prices (particularly food prices). For example, the levels of family assistance allowances, social security, the coverage of minimum wage legislation, the broadening of the vesting of pension rights, unemployment insurance, and the price of the main staples are all of major significance to the nutritional status of much of the citizenry.

Nutrition and Planning of Economic Development

Economists are inclined to view nutrition as one of the unproductive personal and social expenditures that compete with reinvestment. Improvement in nutrition is thus seen as inimical to economic development. The case can be made, however, regarding nutritional expenditures as being, at least in part, an investment: it is becoming clearer that malnutrition during pregnancy, infancy, and early childhood may produce serious consequences for physical and mental development. Large expenditures in health and education later may be necessary to partly reverse these defects, whereas good nutrition during the growth period may contribute positively to productivity. Moreover, nutrition may also be thought of as an organizing principle for development of a sound, stable food industry and its ancillary activities such as packaging and for cutting down food waste, a major factor in all countries.

Neglect of nutrition considerations tends to lead economists to neglect small agricultural enterprises and subsistence agriculture, and thus to ignore the major part of the population in developing countries. The neglect of the importance of fruits, vegetables, small domestic animals, and small-scale production of animal products, which are the major sources of many nutrients in the diet, has led even rapidly developing countries to nutritional disasters at the same time as their gross national product was shooting upward. Ironically, lack of understanding of the role of foodstuffs other than those that are less perishable (cereals, legumes) or easily counted (large farm animals) leads to production figures which are usually underestimates and, hence, to costly mistakes in planning, particularly in import policies. In developing countries, this systematic bias, together with that voluntarily introduced by tax-shy farmers with regard to their production figures, means that consumption studies conducted by home economists often offer a better basis for the evaluation of production figures than do surveys directly attempting to obtain such figures.

Fortification and Other "Instant" Solutions

Economists are constantly on the lookout for cheap and relatively straightforward solutions to nutritional problems. This occasionally degenerates into unwarranted enthusiasm for unproven solutions, such as fortification of staple foods with imported synthetic amino acids. Certainly, there are some well-established examples of the benefits of certain types of fortification. The elimination of goiter through iodization of salt, of rickets and osteomalacia through the fortification of milk with vitamin D (or periodic administration of large doses of vitamin D), the decrease in dental caries through fluoridation of water supply, and the prevention of blindness related to vitamin A deficiency through periodic administration of large doses are well documented. The benefits of other types of enrichment are often more doubtful. Recent data suggesting the importance of fibre and the deleterious effects of high levels of saturated fat, cholesterol, and sugar in the diet add to the complexity of nutrition policy and make us wary of instant solutions. Nonetheless, nutritionists may sometimes be too leery about the possibilities of enrichment and fortification, and prefer instead to advocate foods rich in the missing micronutrients as supplements to the diet; generally, these foods are so expensive that their cost far exceeds that of the enrichment-fortification approach and thus limits the number of persons that can be reached.

Nutrition and the Limitations of Macro-economics

Understandably, perhaps, in view of their training, economists take as gospel the dictum that the primary way to change demand is by income and price alteration. While they are willing to give lip service to education, they are unlikely to take it seriously as an effective intervention technique. Elasticity coefficients derived from income and price relationships in the past are taken as being predictive of what will obtain in the future. Unfortunately, as we have seen in the recent past, in both meat glut and meat scarcity situations, these coefficients do not tell the whole story, however useful they may be.

Furthermore, focusing on aggregate supply and demand may lead to overlooking the importance of certain intervention tactics on groups with low effective demand, such as the poor. Similarly, focusing on society as a whole may lead to ignoring the effects of

interventions on young children and other nutritionally vulnerable groups, who are unable to vote with their purchasing power. Children's diets may be exposed to nutritional risk by the interplays of supply and demand at the macro-economic level, but also at the micro-economic level of the family. Greater attention must be devoted to micro-economics, especially as it applies to individual family members, in the analytical studies of economists.

Essential as income is to nutrition, the problems of malnutrition cannot automatically be solved by income increments. Food beliefs, other health practices deleterious to nutritional status, and maldistribution of food within the family may still be a problem. Income is spent in a variety of ways, only one of which is food. What is seen by the family as discretionary income may vary greatly from one household to the next. Also, even if discretionary income is spent on food, it may be spent on foods that in fact do little to improve nutritional status.

Beyond Food and Economics to Nutrition Policy

Physicians, nutritionists, and economists are not likely to solve the problems they must address within the realm of food policy simply by trading disciplines. Their disciplines are too narrow for this to accomplish much. What is necessary is beyond all of these disciplines, and involves policy-planning objectives based on broader considerations than dollars or health considerations alone. Other humane considerations based on other human values and views must be taken into account. Such policy-planning involves a fusion of disciplines, with different (for instance, health) objectives than would be usual for the discipline of economics and broader intervention strategies than the other professionals would normally employ.

Appendix 'A'

A Glossary of Nutrition

Acetate Replacement Factor

See LIPOIC ACID.

Acetone Bodies

See KETONE BODIES.

Acid Foods

The minerals sodium, potassium, magnesium and calcium are base-forming, and phosphorus, sulphur and chlorine are acid forming. Which of these predominates in a food determines whether that food leaves an acid or alkaline residue after being metabolized. An acid residue is left by meat, fish, eggs, cheese and cereals. An alkaline residue is left by milk, vegetables and some fruits. Fats and sugars are neutral as they contain no minerals at all.

Acid-tasting citrus fruits are actually alkali formers, as, although they contain a mixture of citric acid and sodium citrate, the citric acid and the citrate radical are oxidized to carbon dioxide and water, and the sodium remains as the alkaline residue.

Adenosine Triphosphate (ATP or Adenyl Pyrophosphate)

This is a compound of central importance in the liberation of energy from foodstuffs, consisting of adenine linked to ribose and three phosphate molecules. The last two phosphates are linked by what is called 'the energy-rich phosphate bond'. On hydrolysis they liberate energy for muscular work etc. The energy obtained by the oxidation of carbohydrates, fats and amino acids is trapped as ATP.

Adermin

See VITAMIN B_6.

Adipose Tissue

A group of cells which store and mobilize fat; constitutes 2/5 to 1/4 of the total body mass, more in fat people. It is composed of 60 to 80 per cent fat, 6 to 26 per cent protein and approximately 34 per cent water; calorie value is 6.5 to 7.5 Kcal per g or 3,000 to 3,400 Kcal per lb.

Alanine

A non-essential amino acid, amino propionic acid.

The *alpha* amino acid is found in all proteins; there is also *beta*-alanine (the amino group attached to the second carbon atom) which is part of the molecule of pantothenic acid, of carnosine and of anserine.

Allergy

An altered or abnormal tissue reaction which may be caused by contact between a foreign protein (the allergen) and sensitive body tissues.

Food allergies are more common in infants and the usual causes are eggs, milk and wheat, together with fish and various fruits. The reactions may include nettlerash, hay fever, asthma, and dyspepsia.

Amino Acid

Characterized by an amino group and an acid group attached to the same carbon atom. Proteins are made of combinations of large numbers of amino acids of twenty different kinds.

Eight of these amino acids must be provided in the diet, *i.e.*, the essential amino acids—namely, lysine, methionine, valine, tryptophan, threonine, leucine, isoleucine and phenylalanine. Possibly arginine and histidine are essential for infants.

The remaining twelve can be synthesized in the body so long as a source of nitrogen is available in the diet. These are the non-essential amino acids—histidine, glycine, arginine, alanine, aspartic acid, glutamic acid, proline, hydroxyproline, serine, cystine, cysteine, and tyrosine.

Amino Acids, Antiketogenic

Those which, after deamination, are metabolized to glucose. They are glycine, alanine serine, cystine, aspartic acid, glutamic acid, arginine, proline and hydroxyproline.

Amino Acids, Ketogenic

Those which are metabolized to acetoacetic acid, namely leccine, isoleucine, phenylalanine and tyrosine.

Amino Acid, Limiting

The essential amino acid present in a protein in least amount limits the quality of the protein—this is the limiting amino acid. Most cereal proteins are limited by lysine and most animal foods and vegetables are limited by the sulphur amino acids (methionine plus cystine). In complete diets the sulphur amino acids are limiting.

Lysine is the limiting amino acid in bread protein and it is present at only 45 per cent of the required level. Bread protein is therefore only 45 per cent usable for protein synthesis (if fed alone) *i.e.*, it has a biological value of 45. If lysine is added to bread so that it is no longer limiting the biological value rises to 55 per cent and threonine becomes the limiting amino acid.

Aminopterin

Aminopteroylglutamic acid, specific antagonist to folic acid.

Amla

Considered the parent source of multivitamins in classical treatise.

Anaemia

A shortage of red blood cells. May be caused by a deficiency of any of the factors needed to form red cells, namely protein, iron, vitamins C and B_{12} and folic acid, or damage to the bone marrow.

Nutritional anaemia is the commonest form and is due to iron deficiency. Pernicious anaemia is usually due to a failure to absorb vitamin B_{12}.

Aneurin

See VITAMIN B_1.

Angular Stomatitis

An affection of the skin at the angles of the mouth, characterized by heaping-up of epithelium into ridges, giving the appearance of fissures: may be a symptom of riboflavine deficiency.

Animal Protein Factor

Name given to certain growth factors found in animal but not vegetable proteins. Vitamin B_{12} was identified as one of these.

Anorectic or Anorexigenic Drugs

Drugs that depress the appetite; used as an aid to weight reduction. *E.g.*, amphetamine (or dextroamphetamine or dexedrine), preludin (phenmetrazine hydrochloride), 'Tenuate' (diethylpropion).

Anorexia Nervosa

Psychological disturbance resulting in a refusal to eat; sensations of hunger usually not felt. There may be a restriction of the diet to particular foods. The result is great weight loss, atrophy of tissue and fall in basal metabolic rate.

Anti-Grey Hair Factor

See PARA-AMINO BENZOIC ACID.

Apoferritin

The protein part of ferritin, the iron storage complex in the intestinal mucosal cells.

Arachidonic Acid

Straight-chain fatty acid containing 20 carbon atoms and 4 double bonds (a tetraene). Found only in animal fats *e.g.*, brain, liver, egg yolk. An essential fatty acid.

Arginine

Chemically aminoguanido valeric acid. Dibasic amino acid that is non-essential to adult man. As it is partly essential to

growing rats (growth only 80 per cent of optimum in its absence) it may similarly be partly essential to children. It is essential to the chick.

Ariboflavinosis

Name given to set of symptoms caused by deficiency of riboflavine (vitamin B_2). Characterized by swollen, cracked, bright red lips (cheilosis), enlarged tender, magenta-red tongue (glossitis), cracking at the corners of the mouth (angular stomatitis), congestion of the blood vessels of the conjunctiva.

Ascorbic Acid

See VITAMIN C.

Ascorbic Acid Oxidase

Plant enzyme that oxidizes ascorbic acid. In the living tissue it appears to be separated from the vitamin, but in the wilted, or shredded or bruised leaf the enzyme comes into contact with its substrate and there is a rapid destruction of the vitamin. For preservation of the vitamin in leafy vegetables during cooking it is recommended that the vegetables be plunged into boiling water to destroy the enzyme.

Aspartic Acid

A non-essential dibasic amino acid; amino succinic acid. Its amide is asparagine.

ATP

Adenosine triphosphate.

Atwater Factors

The number of kilocalories of *available* energy obtained per gram of food principles, namely, carbohydrate 4.0, protein 4.0, fat 9.0. The factors were derived by Atwater from the heat of combustion of these food principles (4.1, 5.7 and 9.4) corrected for incomplete digestion and absorption.

AT-10

See TACHYSTEROL.

Avidin

Protein in white of egg which combines with vitamin H (biotin), and renders it unavailable to the body. It is inactivated by cooking.

Avitaminosis

Absence of a vitamin; may be used specifically, as 'avitaminosis A'.

Axerophthol

Name once suggested for vitamin A but not adopted.

Basal Metabolic Rate

When the body is at complete rest, free from draughts, at moderate room temperature and 12 to 14 hr after a meal, energy is being used at the basal rate—the basal metabolism. This energy is needed to maintain the heart beat, respiration, etc., but largely to maintain body temperature and the tension of the muscles. BMR is therefore related to muscle mass and the surface area of the body.

It may be calculated from surface area, *e.g.*, a 22-year-old male expends 32 to 43 kcal/sq m/hr, and the output per sq m varies with age and sex.

A simplified measure of BMR is:

men: kcal per 24 hr = 850 + 36.6 W (wt in kg)

women: 580 + 31.3 W

See also SURFACE AREA.

Beriberi

Result of a severe vitamin B_1 deficiency; common in the Far East where white (polished) rice forms the bulk of the diet and vitamin B_1 is poorly supplied.

There are two forms of beriberi; the wet form—where oedema is present—and dry beriberi—where there is extreme emaciation. In both forms there is a degeneration of the nerves affecting the lower limbs first, gastrointestinal disorders, mental symptoms, an enlarged heart with an increased rate of beat, and death ultimately results from cardiac failure.

Beta-oxidation

One of the routes of fatty acid metabolism—oxidation at the carbon atom *beta* to the carboxyl group of the fatty acid, *i.e.*, next but one, with the formation of the *beta*-ketonic acid. Acetic acid then splits off, leaving a fatty acid two carbon atoms shorter than the original.

Biocytin

A lysine derivative of biotin that occurs naturally; not fully usable by all organisms until it has been hydrolysed to free biotin.

Bioflavonoids

Alternative name for group of flavonoids which exhibit pharmacological activity.

See VITAMIN P.

Biological Value

With reference to proteins biological value is a quantitative measure of their nutritional value. The measurement is carried out on animals or man and is the amount of protein, when fed under standard conditions, that is retained in the body for synthesis of body protein.

B.V. is expressed on the percentage scale *i.e.*, 100 is the 'perfect' protein. Examples: egg 95, meat 75, fish 75, milk 75, bread 50, peanut 45, wheat gluten 45, gelatin nil. These figures refer to the substance fed as the only protein in the diet, whereas normally they are eaten in admixture with other proteins and complement each other.

The fact that animal proteins have higher B.V.'s than vegetable proteins led to the distinction into *first class* and *second class* proteins. As, however, mixtures of vegetable proteins, and certainly mixtures of animal and vegetable proteins can have as high a B.V. as many animal proteins, this distinction has been discarded.

Bios

During the early investigations into the factors necessary for yeast growth it was found that a substance derived from yeast had to be added to the medium. This was called bios. It was later fractionated into Bios I, identified as inositol and Bios II, identified as biotin.

Biotin

Also known as vitamin H, identical with bios IIB and with coenzyme R (growth factor and respiratory stimulant for the organism Rhizobium, present in the root nodules of legumes).

Essential to a wide variety of animals, including man, but synthesized in the intestine. It is inactivated by combination with avidin, a protein in raw egg-white, and deficiency symptoms can be produced by feeding raw (but not cooked) egg-white. Deficiency causes dermatitis, loss of fur and disturbance of the nervous system in experimental animals.

Present in liver, kidney, egg yolk, yeast, vegetables, grains, nuts.

Bitot's Spots

Foam-like irregular plaques on the surface of the eye due to vitamin A deficiency.

Bland Diet

One that contains the minimum of crude fibre or roughage and is therefore non-irritating and soothing to the intestine.

Bradycardia

An unusually slow heart-beat; a symptom, among other causes, of certain vitamin deficiencies.

Browning Reaction

See MAILLARD REACTION

Calciferol

See VITAMIN D.

Calcium

A dietary essential needed for the formation of bones and teeth, which are composed largely of calcium phosphate. Calcium is present in the body in large amounts than any other mineral (1.0 to 1.5 kg).

The small amount circulating in the blood (9 to 11 mg per 100 ml) and in the soft tissues plays a vital part in the metabolic processes, controls the heart beat and the excitability of muscle

and nerve, plays a part in blood clotting and in the maintenance of acid-base equilibrium. A fall in the level of blood calcium results in increased sensitivity of the motor nerves to stimuli, *i.e.*, tetany.

Its absorption from food is aided by vitamin D and protein and hindered by excess fat, phosphate, oxalate and phytate, the result is that only 15 to 35 per cent of dietary calcium is absorbed.

Daily requirements 0.4 to 0.5 g increased to 0.4 to 0.7 g in growing children, and 1.0 to 1.2 g in pregnancy and lactation (F.A.O. 1962).

Richest sources are milk and cheese; calcium is added to flour as *creta praeparata* at the rate of 14 oz per 280 lb sack: eggs and vegetables are moderate sources.

The chemical form in which calcium is added to foods for enrichment does not appear to be important, *e.g.*, carbonate, phosphate, chloride, etc., appear to be equally well absorbed.

Calcium-Phosphorus Ratio

Earlier work suggested that a high ratio of phosphate to calcium in the diet hindered the absorption of calcium from the intestine into the blood stream and gave rise to rickets. It was thought that a Ca:P ratio of between 1:2 and 2:1 was essential for maximum absorption but this belief has been discarded.

Calorie

The unit of heat used in nutrition is the kilocalorie—the amount of heat required to raise the temperature of 1 kg of water from 14.5 to 15.5°C (58 to 60°F).

Calorie Conversion Factors

Rubber: carbohydrate 4.1, protein 4.1, fat 9.3.

Atwater: (allowing for losses in digestion, absorption and incomplete metabolism) carbohydrate 4, protein 4, fat 9. For alcohol the factor is 7.

Calories, Empty

Refers to foods that supply energy alone (*i.e.*, calories) without any other nutrients such as vitamins, proteins or minerals. For example, sugars are pure carbohydrate and provide calories only. The term empty calories is met in connection with slimming diets.

Calorimeter (or Bomb Calorimeter)

Instrument for measuring the amount of oxidizable energy present in a substance by burning it is oxygen and measuring the heat released. The heat liberated by burning a food in this way will coincide with the metabolizable energy in that food only if it can be completely metabolized. *E.g.*, proteins liberate 5.65 kcal/g in the bomb calorimeter in which the nitrogen is oxidized to the dioxide, but only 4.4 kcal/g in the body where the nitrogen is excreted as urea and uric acid, etc., (containing 1.25 kcal/g).

Calorimetry, Direct

Direct measurement of heat production. It is measured in man in a respiration calorimeter (*e.g.*, Atwater-Benedict type); the subject is placed inside the calorimeter, which is effectively a small room with insulated walls. The heat produced is measured by the rise in temperature of water flowing round the walls. This type of apparatus was used in the early days of research into energy metabolism.

Calorimetry, Indirect

Measurement of energy output by calculation from the oxygen consumption and carbon dioxide output. *See* SPIROMETER.

Canthaxanthin

A red carotenoid pigment, chemically related to *beta*-carotene but without any vitamin-A activity. Suggested use as addition to the diet of broiler chickens to impart a pigmented skin and shanks, and to the diet of trout to produce the bright colours of wild trout; these colours are normally derived from natural foodstuffs which may be variable or in short supply.

Similarly *beta*-apo-8'-carotenal, which is four-fifths of the *beta*-carotene molecule, can be used in chick diets to increase the colour of the egg yolks.

Capillary Fragility

Refers to the resistance to rupture of the walls of a blood vessel, which would result in the leakage of blood into the tissue spaces. There is some evidence that the flavonoids (*See* VITAMIN P) increase the resistance to rupture and this has given rise to

unverified suggestions that this group of compounds will protect against the common cold by increasing the resistance of the capillaries to infection.

Carbohydrates

Substances containing carbon, hydrogen and oxygen, such as sugars, starch, dextrins and glycogen. They are broken down both by acid hydrolysis and enzymic digestion to simple sugars, such as glucose, fructose and galactose.

Carbohydrates liberate and average of 4 kcal per g (114 per oz) when oxidized to carbon dioxide and water. They form the major part of the diet in most countries.

Certain carbohydrates are not hydrolysed by the digestive enzymes and do not serve as a dietary source of energy, these include cellulose, pectins, agar, alginic acid.

Carbohydrates, Unavailable

This term refers to pentosans, pectins, hemicellulose and cellulose which are not digested by monogastric animals but only by ruminants.

Carnitine

Plays a role in transferring the acetyl group from inside the mitochondrion to the outside where fat synthesis takes place.

Occurs in animal muscle and is particularly rich in meat extract but is not dietary essential for man and the higher animals. The only organisms that have been shown to require carnitine as a dietary essential are the mealworm and a few related species; it was originally called vitamin B_T.

Carotenal—or Apo-8-carotenal

A modified form of *beta*-carotene found in the intestine and is possibly the first intermediate in the conversion of carotene to vitamin A. Also found in nettles, spinach and citrus fruits. When fed to laying chickens it is deposited in the egg yolk and so it is added to chick diet or produce deeply coloured yolks.

Carotene

Red pigment in plants and green leaves, obvious in carrots,

red palm oil and yellow maize, masked by chlorophyll in leaves.

It is pro-vitamin A as it is converted into this vitamin in the body. About one-third of the vitamin A of western diets is supplied as carotene. Present to only a limited extent in animal tissues, for example there is some carotene as well as vitamin A in milk.

Occurs in three forms, *alpha, beta* and *gamma* carotenes, and lends name to a range of pigments of similar structure—the carotenoids—only a few of which are vitamin A precursors.

Before the preparation of pure vitamin A alcohol, *beta*-carotene was used as the vitamin A standard—0.6 microgram of *beta*-carotene = 1 i.u. of vitamin A. *Alpha* and *gamma* carotenes have only half the vitamin A potency of *beta*-carotene.

Used as a colouring material in foods and as a source of vitamin A in vegetarian and kosher margarines.

Carotenoids

A group of yellow to red pigments occurring widely in plants and animals and structurally related to carotene. Some are converted into vitamin A in the body, the carotenes, cryptoxanthin, echinenone, torularhodin, and apocarotenal, others are not, *e.g.* canthaxanthin, lycopene, zeaxanthin, bixin.

CF

See CITROVORUM FACTOR.

Chastek Paralysis

Acute dietary disease of foxes caused by the inclusion of 10 per cent of raw fish in the diet. It is due to a deficiency of vitamin B_1 caused by the presence of the enzyme, thiaminase, in the fish, which destroys the vitamin. It is cured by adding vitamin B_1 to the diet.

Cheilosis

See ARIBOFLAVINOSIS.

Chemical Score

A chemical method of defining the nutritional value of proteins, proposed by Block and Mitchell (1946). The limiting amino acid

in the protein under consideration is expressed as the percentage of the same amino acid present in egg (taken as the standard). Chemical score numerically equals biological value.

A later modification is Protein Score, in which a standard amino acid reference mixture is used instead of egg protein.

Cholecalciferol

See VITAMIN D.

Cholesterol

See STEROLS.

Choline

Essential dietary factor, trimethyl hydroxyethylammonium hydroxide, usually classed as a vitamin, although the quantities involved are far from catalytic. Functions as a source of methyl groups and in fat transport; deficiency gives rise to fatty infiltration of the liver; is part of the structure of the phospholipids of animal and plant tissues. Specific dietary deficiency does not occur; daily requirements not established but the daily intake is 0.25 to 0.5 g.

Citric Acid Cycle

The oxidation stage in the metabolism of foodstuffs. Carbohydrates and fats are broken down to acetate (active acetate or acetyl coenzyme A) and the first step in the cycle is the combination of the acetyl with oxaloacetate to form citrate. This passes through a series of reactions in which energy is released and carbon dioxide and water produced; the end-product is oxaloacetate.

As many of the amino acids can be converted into substances that lie on this pathway, the citric acid cycle is the common metabolic pathway for all three major foodstuffs. Also known as the Krebs' cycle.

Citrin

A mixture of two flavanones found in citrus pith, namely hesperidin and eriodictin (demethylated hesperidin). *See also* VITAMIN P.

Citrovorum Factor

Name given to a growth factor for the organism *Leuconostoc citrovorum*. Now known to be tetrahydro formyl pteroyl glutamic acid, which is believed to be the active form of the vitamin, folic acid.

Citrulline

Amino acid formed as an intermediate in the metabolism of urea in the body. Not of nutritional importance as it is not found in food proteins.

CoA

Abbreviation for Coenzyme A.

Cobalamin

Vitamin B_{12}.

Cocarboxylase

Coenzyme that assists the enzyme carboxylase to remove carbon dioxide from various compounds, *i.e.*, decarboxylation.

Cocarboxylase is the diphosphate of vitamin B_1, alternatively known as thiamine pyrophosphate or diphosphothiamine. In a deficiency of vitamin B_1 the body is unable to oxidize pyruvic acid, an intermediate stage in carbohydrate metabolism, which therefore accumulates in the blood.

Cod-Liver Oil

Oil from codfish liver; classical source of vitamins A and D, and, indeed, was recommended for its medicinal properties long before the vitamins were discovered.

Contains 400 to 4,000 i.u., vitamin A and 40 to 400 i.u. vitamin D per g.

B.P. cod liver oil, minimum 600 i.u. vitamin A and 85 i.u. vitamin D per g.

Coeliac Disease (Idiopathic Steatorrhoea or Non-tropical Sprue)

A disease of unknown origin, usually beginning in early

childhood, due to an idiosyncrasy to wheat gluten. Characterized by fatty stools, diarrhoea, loss of appetite and failure to grow. The lining of the intestine is severely damaged by the wheat gluten and removal of this from the diet lead to recovery. Hence the use of 'gluten-free bread' and 'gluten-free biscuits'.

At one time it was thought that bananas had some therapeutic value and coeliac disease was sometimes called banana disease, but it is know known that the effect was merely due to the replacement of some of the wheat gluten of the diet.

As well as wheat gluten the subject cannot tolerate rye protein but maize and rice gluten are thought to be harmless.

Coenzyme A

Coenzyme for the transfer of acetyl groups; contains the vitamin, pantothenic acid. Functions by its ability to combine with acetyl, forming acetyl CoA, and to transfer this to other compounds. Important in the oxidation of glucose at the stage between pyruvic acid and the citric acid cycle, and in fat metabolism.

Coenzyme I

Complex of nicotinamide with adenine, two molecules of ribose and two molecules of phosphate. Also known as DPN or diphosphopyridine nucleotide, as Euler's yeast coenzyme, as cozymase and as CoI. Many dehydrogenases require the presence of CoI before they can function, hence it is an essential part of the cell oxidation system and explains the vitamin function of nicotinic acid.

Official name, nicotinamide adenine dinucleotide or NAD.

Coenzyme II

Complex of nicotinamide with adenine, two molecules of ribose and three molecules of phosphate (one more than CoI). Also known as TPN or triphosphopyridine nucleotide, and Warburg and Christian's coenzyme. Many dehydrogenases require the assistance of CoII, others require CoI, and still others function without a coenzyme. CoII is thus an essential part of cell oxidation systems.

Official name, nicotinamide adenine dinucleotide phosphate or NADP.

Copper

Copper is part of the enzyme tyrosinase (and in plants, laccase and ascorbic acid oxidase) and is needed to assist the incorporation of iron into haemoglobin. It is therefore thought to be a dietary essential in amounts of about 2 mg per day, but there is no evidence that a dietary deficiency ever occurs in man. Traces of copper are normally present in the blood in combination with an alpha globulin as caeruloplasmin.

Deficiency in cattle gives rise to 'swayback'. Traces are also essential for plant growth.

Toxic in high concentrations and there is a legal limit to the amount permitted in foodstuffs.

Cow Manure Factor

Vitamin B_{12}.

Cozymase

See COENZYME I.

CoI and CoII

Abbreviation of COENZYMES I and II.

Creta Praeparata

Official British Pharmacopoeia name for prepared chalk, made by washing and drying naturally—occurring calcium carbonate. The form in which calcium is added to flour in U.K. (14 oz per 280-lb sack).

Cryptoxanthin

Yellow colouring matter in certain vegetables such as yellow maize, and in the seeds of Physalis, the Chinese Lantern. A hydroxy derivative of carotene; converted into vitamin A in the body.

Cyanocobalamin

Vitamin B_{12}.

Cysteine

Aminothiol propionic acid. *See* CYSTINE.

Cystine

One of the three sulphur-containing amino acids—cystine, cysteine and methionine. Chemically consists of two molecules of cysteine joined via the -S-S-link. Methionine is the essential sulphur amino acid and cystine is non-essential, but can replace part of the methionine of the diet. Hence the S amino acids are always considered together. *See* METHIONINE.

Dark Adaptation

This is the change that takes place in the retina of the eye to assist vision in dim light. In dark adaptation a pigment, visual purple or rhodopsin, is formed from vitamin A aldehyde and a protein. This is bleached in bright light. When body stores of vitamin A are inadequate poor dark adaptation—night blindness—results. This is the earliest indication of vitamin A deficiency.

Dehydroascorbic Acid

Oxidized form of vitamin C which can readily be reduced to the ordinary form, and is therefore biologically active.

Dehydrocholesterol

See VITAMIN D.

Derbyshire Neck

See IODINE AND GOITRE.

Diets

See under individual entries—SODIUM-FREE, KETOGENIC, SALISBURY, HAY, KARELL, KEMPNER, LENHARTZ, MEULENGRACHT, SIPPY.

Digestibility

The proportion of a foodstuff absorbed from the digestive tract into the bloodstream, normally 90 to 95 per cent. It is measured as the difference between intake and faecal output, making allowance for that part of the faeces which is not derived from undigested food residues (such as shed lining of the intestinal tract, bacteria, residues of digestive juices).

Digestibility measured in this way is referred to as 'true

digestibility' as distinct from the approximate measure of 'apparent digestibility' which is simply the difference between intake and output.

Diphosphopyridine Nucleotide

See COENZYME I.

Diphosphothiamine

See COCARBOXYLASE.

DPN

See COENZYME I.

DU Bois Formula

See SURFACE AREA.

Dyspepsia

Any pain or discomfort associated with eating, Dyspepsia may be a symptom of gastritis, peptic ulcer, gall-bladder disease, etc., or, if there is no structural change in the intestinal tract it is called 'functional dyspepsia'. Treatment includes a bland diet.

Egg-white Injury

See BIOTIN.

Embden-Meyerhof-Parnas Scheme

Name for the first series of steps in the breakdown of glucose in the tissues, as far as pyruvic acid, *i.e.*, the glycolytic part as distinct from the subsequent oxidation.

Energy-rich Phosphate

See PHOSPHATE BOND, ENERGY-RICH.

Enrichment

Term applied to the addition of nutrients to foods. *E.g.*, addition of vitamins A and D to margarine, extra vitamin C to fruit juices, iodide to table salt, B vitamins to flour and rice.

The terms ennoblement and fortification are also applied to these producers.

Ergocalciferol

See VITAMIN D.

Ergosterol

Sterol isolated from yeast; when treated with ultraviolet light is converted to vitamin D_2 (calciferol); this is the method of manufacture of the vitamin.

Eriodictin

See VITAMIN P.

Erythorbic Acid

Alternative name for iso-ascorbic acid, an isomer of ascorbic acid; has only slight vitamin C activity.

Has strong reducing properties and has been used as an antioxidant in food, and to preserve the red colour of fresh or preserved meats.

Essential Fatty Acids

Collective name for the two unsaturated fatty acids, linoleic (18 carbon chain, two double bonds) found in vegetable oils, and arachidonic (20 carbon chain, four double bonds) found in animal tissues. They are dietary essentials for experimental animals: formerly called vitamin F, are also known as the polyunsaturates.

Deficiency in animals causes restriction of growth, abnormalities of skin and hair, damage to reproductive system, and abnormal composition of serum and tissue fatty acids. The need for EFA for man is not established (there are claims that babies suffer skin disorders in their (absence). It has been claimed that a high dietary level of these unsaturated fatty acids lowers blood cholesterol levels and may therefore be beneficial in atherosclerosis.

EFA are poorly distributed in animal fats and occur mainly in vegetable oils especially safflower, sunflower and corn oils, hence the use of these oils in diets sometimes recommended for the treatment of atherosclerosis.

Extrinsic Factor

See INTRINSIC FACTOR.

Factor 3

First described in 1941 as an unknown agent present in wheat germ, wheat bran and whey, which protected rats against dietary necrosis of the liver. Also protected against multiple sclerosis in mice, exudative diathesis in chicks and muscular dystrophy in mink. So called as it was the third agent, the others being vitamin E and cystine, that was shown to be protective.

Now known to be an organic derivative of selenium, and the protective action of cystine is due to selenium contamination. Selenium compounds differ in their potency; selenate, selenite, selenium analogues of cystine, cystathione and methionine are effective at 2 to 3 micrograms per 100 g diet. Factor 3 is effective at 0.7 micrograms; one atom of selenium in this form is equivalent to 700 to 1,000 molecules of vitamin E.

Importance to man unknown.

FAD

Flavine Adenine Dinucleotide.

Fat-soluble Vitamins

Vitamins A, D, E and K; occur in food in solution in the fats. Are stored in the body to a great extent than the water-soluble vitamins. The distinction into fat-soluble and water-soluble is of historical interest and is convenient for chapter headings in text-books, but otherwise has no significance.

Fatty Acids, Essential

See ESSENTIAL FATTY ACIDS.

Ferritin

A ferric-hydroxide-phosphate-protein complex (containing 23 per cent iron) present in the cells of the intestinal mucosa, liver, spleen and bone marrow, as a storage form of iron. *See also* HAEMOSIDERIN.

Filtrate Factor

See PANTOTHENIC ACID.

Flavine Adenine Dinucleotide

Or FAD. A coenzyme in cellular oxidation consisting of the vitamin riboflavine, attached to two phosphate molecules, and ribose and adenine. *See* FLAVOPROTEINS.

Flavoproteins

A group of oxidizing enzymes composed of conjugated proteins containing riboflavine (vitamin B_2) as the prosthetic group. There are two classes, those containing flavine mono-nucleotide, and those containing flavine-adenine dinucleotide. The protein itself differs in each specific enzyme. Examples, amino acid oxidase (oxidizes amino acids to ketonic acids), cytochrome reductase (part of the oxidation chain in the cell), diaphorase and Warburg's yellow enzyme (also part of the oxidation chain).

Folacin

Term adopted in 1949 by the American Institute of Nutrition to replace folic acid.

Folic Acid

Vitamin essential in the synthesis of purines and pyrimidines and certain amino acids. General name given to a group of related compound with similar biological action; includes pteroylglutamic acid (PGA), *Lactobacillus casei* factor (= pteroyl triglutamic acid), vitamin B_c (= pteroyl hepta glutamic acid), *Streptococcus lactis* R factor or Rhizopterin (= formyl pteroyl glutamic acid), leucovorin or citrovorum factor (= tetra hydro formyl PGA), vitamin M, factor U, Wills factor.

The basically active form appears to be tetra hydroformyl-pteroyl-glutamic acid—folinic acid.

Deficiency causes a variety of symptoms but most specifically megaloblastic anaemia.

Occurs widely in a variety of foods (liver, yeast, vegetables, fruits, cheese). Daily requirements not established but about 50 micrograms. Deficiency usually associated with defect in absorption and utilization rather than dietary insufficiency but recently mild cases of deficiency have been found in pregnant women and elderly persons which may be due to inadequate diets.

Folinic Acid

See Folic Acid.

Fortification

See Enrichment.

Galactosaemia

Inherited inability to metabolize the sugar galactose beyond the formation of its phosphate. Unless galactose is excluded from the diet the subject suffers mental retardation, growth failure, vomiting and jaundice. Some baby foods are therefore prepared entirely free from lactose.

Genetic Disease

In connection with food the inherited inability to metabolize certain dietary factors, often with harmful results. *See* Phenylketonuria, Galactosaemia, Tyrosinosis.

Glossitis

See Ariboflavinosis.

Glucoascorbic Acid

Homologue of ascorbic acid containing an extra CHOH group. Acts as an antagonist to the vitamin; its administration can cause scurvy in animals that do not normally require the vitamin in the diet.

Glutamic Acid

A non-essential amino acid, amino glutaric acid. Involved in transamination reactions in the body; its amide is glutamine.

The sodium salt, monosodium, glutamate or MSG, originally known as Aginomoto, is used to enhance the flavour of savoury dishes and is frequently added to canned meat and soups.

Gluten-free Foods

Formulated without any wheat or rye protein (although the starch may be used), for subjects suffering from coeliac disease.

Glycine

A non-essential amino acid, chemically amino acetic acid, CH_2NH_2COOH. Clinically used as a buffer for gastric acidity.

Has 70 per cent of the sweetness of sucrose and is sometimes used mixed with saccharine as a sweetening agent.

Glycogen

Storage form of carbohydrate in the animal body, in the liver and muscles. Composed of glucose units; is synthesized from the blood sugar and broken down to blood sugar as required. Sometimes referred to as animal starch.

In an adult man the glycogen stored in the muscles is about 250 g and in the liver about 100 g.

As glycogen is rapidly broken down to glucose immediately an animal is killed, meat and animal liver do not contain glycogen, the only dietary sources are oysters, cockles, mussels, clams, scallops, whelks and winkles which are eaten virtually alive and contain about 5 per cent glycogen.

Glycogenesis

Synthesis of glycogen from glucose, as, for example, occurs in the muscle where glucose is stored as glycogen; facilitated by insulin.

Glycogenolysis

Breakdown of glycogen to glucose when this is required for the production of energy.

Glycolysis

There are two parts to the total breakdown of glucose, the first is anaerobic and called glucose fermentation or glycolysis. This ends at the formation of pyruvic acid. The second part is an oxidation and the series of reactions is the Krebs' tricarboxylic acid cycle, or the citric acid cycle. This completes the breakdown to carbon dioxide and water.

Goitre

Enlargement of the thyroid gland, seen as a swelling in the neck, due to deficiency of iodine in the diet and to the presence

of 'goitrogens' in certain foods such as Brassicas and peanuts.

Supplementation with an iodide often prevents the condition, hence the use of iodized salt.

Haemopoietic Factor

See INTRINSIC FACTOR.

Haemosiderin

Brown granular pigment composed of iron-protein complex, present in various tissues. It is a storage form of iron that can be mobilized for haemoglobin synthesis but is only present when there are ample stores of ferritin. It accumulates in the spleen, liver and bone marrow—siderosis—in diseases where there is excessive destruction of blood. Siderosis also occurs on poor diets rich in iron.

Haff Disease

A paralysis due to the excessive consumption of various freshwater fish (probably inadequately cooked) which contain the anti-vitamin antithiamine. Occurs in Sweden and is the human equivalent of Chastek's paralysis which affects foxes.

Hay Diet

A system of eating based on the fallacy that carbohydrates and proteins should not be eaten at the same meal. As protein, in the absence of adequate carbohydrate, is oxidized to provide energy and therefore not available for tissue building, this diet is not only faddish but foolish.

Hesperidin

At one time called vitamin P as it affects the fragility of the capillary walls. Found in the pith of the unripe orange and other citrus fruits; chemically a complex of glucose and rhamnose with the flavanone, hesperitin.

Hess Test

A test for capillary fragility in scurvy. A slight pressure is applied to the arm for five minutes and a shower of petechiae (minute haemorrhagic spots) appear on the skin below the area of application.

Hexose Monophosphate Shunt

An alternative pathway in the metabolism of glucose to the Embden Meyerhof-Parnas pathway. The glucose-6-phosphate formed in the main route can be converted to phosphogluconic acid, then to pentose phosphates and to sedoheptulose-7 phosphate. The latter then joins back into the main pathway.

As pentoses are formed it is also referred to as the pentose cycle.

Histidine

As amino acid essential to the growing rat but not to adult man. It is assumed that it is essential to the growing child. Chemically amino iminazole propionic acid.

Decarboxylation produces histamine.

Hydroxyproline

A non-essential amino acid. Chemically hydroxypyrrolidine carboxylic acid.

Hypercalcaemia (Idiopathic)

Increased levels of calcium in the blood; affects infants and can be fatal. The cause is not established but is believed to be due to hypersensitivity to vitamin D leading to excessive absorption of calcium into the bloodstream. Symptoms include loss of appetite, vomiting, wasting, constipation, flabby muscles; there can be abnormal calcification of the kidneys.

Hypervitaminosis

Overdosage with vitamins. In most cases there is no ill-effect, but hypervitaminosis A and also D have ill-effects; overdosage with nicotinic acid causes flushing of the face and neck.

Incaparina

A protein rich dietary supplement developed by the Institute of Nutrition of Central America and Panama (INCAP). One version consists of 38 per cent cottonseed flour, 29 per cent ground corn, 39 per cent sorghum, 3 per cent Torula Yeast, 1 per cent calcium carbonate and 4,500 i.u., vitamin A per 100 g. Incaparina 9A includes 58 per cent maize and 38 per cent cottonseed flour; in

formula 14 the cottonseed is replaced by soya.

Indian Multipurpose Food (MPF)

A blend of 75 parts low-fat peanut flour and 25 parts Bengal-gram flour, plus vitamins and calcium.

The American MPF is based on soya.

Inositol

Essential nutrient for micro-organisms and many animals and so classed as a vitamin, although there is no evidence of its essentiality for man. Deficiency causes alopecia in mice and 'spectacle eye' (denudation around the eye) in rats.

Chemically hexahydrocyclohexane $(CHOH)_6$; there are nine stereoisomers of this compound but only one, meso- or myo-inositol, is of major interest. It occurs widely in plant and animal tissues as an essential part of the structure and in combination in phosphatides. Its hexaphosphoric acid ester is phytic acid, *which see.*

Obsolete names inosite and meat sugar. The insecticide gammexane is hexachlorocyclohexane, and appears to function by competing with inositol.

Intrinsic Factor

Vitamin B_{12} from the diet (formerly known as the extrinsic factor) appears to require an unidentified substance from the gastric mucosa (known as intrinsic factor) either to aid its absorption or to form a complex called the haemopoietic factor. This complex, or the B_{12}, is stored in the liver and is essential for the synthesis of the nucleoproteins of the red blood cells.

In pernicious anaemia there appears to be a deficiency of the intrinsic factor and the vitamin B_{12} is not absorbed. Treatment is by administering B_{12} intravenously, or orally in conjunction with dried hog mucosa (which contains intrinsic factor) or by injecting the complete haemopoietic factor as liver extract.

Iodine

A trace element required at the level of 150 micrograms per day. It is part of the hormones thyroxine and triiodothyronine produced by the thyroid gland; prolonged shortage of iodide in

the diet leads to goitre.

It is plentifully supplied by sea foods and by vegetables grown in soil containing iodide. Goitre can occur in defined geographical areas where the soil water is deficient in iodide. For example, in England it occurs in Derbyshire, where it is known as *Derbyshire neck,* and in Oxfordshire; there are goitrous areas in most countries, *e.g.*, Switzerland, U.S.A., New Zealand and many of the developing countries.

Iodine is not essential to plant growth but is present in plants in amounts varying with the level in the soil.

Iodized Salt

Contains added potassium (or sodium) iodide, 433 to 725 micrograms per oz (as well as a small amount of magnesium carbonate to improve the free-running qualities); *i.e.*, 15 to 30 parts of iodide per million of salt.

Used as a prophylactic for iodine-deficiency goitre.

Iron

A mineral essential to the body; the average adult has 4 to 5 g of iron of which 60 to 70 per cent is present as haem in the circulating haemoglobin and the remainder present in various enzymes (*e.g.*, catalase, cytochrome oxidase) in muscle myoglobin or stored. About 15 per cent of the iron is stored in the liver as ferritin, in other tissues as haemosiderin, and as the blood transport complex called transferrin (average blood level 50 to 180 micrograms of iron per 100 ml plasma).

Iron balance: losses in faeces 0.3 to 0.5 mg per day, in sweat as skin cells 0.5, traces in hair and urine, total loss 0.5 to 1.5 mg per day; diet contains 10 to 15 mg of which 0.5 to 1.5 mg is absorbed.

Recommended intake 12 mg for adults, 15 mg during pregnancy and lactation and for adolescents, 7.5 to 10.5 mg for children rising to 13.5 mg in 11 to 14 year old group. Absorption aided by vitamin C and reduced by phosphate and phytic acid.

Content of foods: liver—6 to 14 mg per 100 g, cereals—up to 9 mg, nuts—1 to 5 mg, eggs—2 to 3 mg, meat—2 to 4. Added to flour in U.K., so that it contains not less than 1.65 mg per 100 g. Fortified cereals provide 35 per cent of the iron of British diets.

Prolonged deficiency gives rise to nutritional anaemia.

Isoascorbic Acid

Also known as Erythorbic Acid, *which see.*

Isoleucine

An essential amino acid, rarely limiting in foods. Chemically aminomethyl valeric acid.

Isoriboflavine

An analogue of riboflavine containing the two methyl groups in the 5,6 instead of the 6,7 positions. It competes with the vitamin and so inhibits growth.

Karell Diet

For patients with severe cardiac failure. It is a low-calorie fluid diet consisting of 800 ml milk given in four feeds; it provides 500 kcal, 28 g protein, and 0.45 g (20 mEq) of sodium and is given for only two or three days.

Kempner Diet

Or rice diet. A diet low in salt comprising rice, fruit, fruit juices, sugar and vitamins, containing about 2,000 kcal, 15 to 30 g protein and 100 to 150 mg sodium per day for patients suffering from congestive heart failure, cirrhosis of the liver, hypertensive disease, toxaemias of pregnancy and certain kidney disorders.

Ketogenic Diet

A diet poor in carbohydrate (20 to 30 g) and rich in fat; causes accumulation of the ketone bodies in the tissues; used to be used in the treatment of epilepsy.

Ketone Bodies

Name given to the penultimate products of fatty acid metabolism—acetoacetic acid betahydroxybutyric acid and acetone. They can be oxidized at only a limited rate, and when their production rate is excessive, as in diabetes and starvation, they accumulate in the blood (ketonaemia), and are excreted in the urine (ketonuria).

Kilocalorie

See CALORIE.

Krebs' Cycle

See CITRIC ACID CYCLE.

Kwashiorkor

A form of malnutrition in infants due to shortage of protein associated with adequate or near adequate carbohydrate intake. Occurs in infants weaned on to a low-protein diet and the name is from the Ga language of Ghana used to describe the sickness of the first child when a second child is born (and the first one has to be weaned on to an inadequate diet). It is common in most tropical countries in the age-group 1 to 3 years.

Symptoms include poor growth, oedema, wastage of the muscles, mental apathy, fatty infiltration of the liver.

Lenhartz Diet

For peptic ulcer patients; similar to the SIPPY DIET, *which see, i.e.*, milk at hourly intervals, but with more protein by the addition of eggs.

Leucine

An essential amino acid; rarely limiting in foods. Chemically amino isocaproic acid.

Leucovorin

Growth factor for *Leuconostoc citrovorum*, one of the forms of folic acid.

Linoleic Acid

Straight-chain fatty acid with 18 carbon atoms and two double bonds, (a diene): $C_{17}H_{31}COOH$, double bonds 9 to 10 and 12 to 13 carbons (octadecadienoic acid). *See* ESSENTIAL FATTY ACIDS.

Linolenic Acid

Straight-chain fatty acid of 18 carbon atoms with three double bonds; $C_{17}H_{29}COOH$ with double bonds at 9 to 10, 12 to 13 and 15 to 16 carbons (octadecatrienoic acid). A major component of

linseed oil and its high degree of unsaturation is responsible for the drying properties of the oil. (At one time included with the essential fatty acids.)

Lipoic Acid

Essential growth factor for various micro-organisms; discovered in yeast and liver-extracts and called by various workers, acetate replacement factor, pyruvate oxidation factor, thioctic acid and protogen. Chemically it is dithio-octanoic acid.

In combination with vitamin B_{12} phosphate and coenzyme A, lipoic acid forms lipothiamide, essential for oxidative decarboxylation in carbohydrate metabolism.

Lipothiamide

See LIPOIC ACID.

Luxus Konsumption

A theory that 'normal' people manage to keep their weight within reasonable limits by burning off any excess of food, while obese people suffer a failure of this mechanism.

Lycopene

Red pigment found in tomato, pink grapefruit and palm oil, straight chain derivative of carotene with no vitamin A activity. The synthetic material is sometimes used as a food colour.

Lysine

An essential amino acid of special importance as it is the limiting amino acid in many foodstuffs, including cereals. It can be synthesized on the commercial scale, and when added to bread or rice or cereal-based animal feeds, it improves the nutritive value of the protein.

It is dibasic and can be produced as the free lysine, and the mono- and dihydrochlorides, and appears to occupy a special position in amino-acid metabolism as it has a low 'turn-over rate' in the body compared with other amino acids. Chemically diaminocaproic acid.

Magnesium

An element that is essential to the diet although no deficiency has ever been shown in man. It is present in bone and magnesium ions are necessary in many enzyme reactions.

Deficiency in cattle gives rise to grass tetany. Magnesium is part of the molecule of chlorophyll and is therefore present in all green foodstuffs. If the soil is deficient in this element the resultant deficiency in chlorophyll produces a pale plant suffering from 'chlorosis'.

Maillard Reaction

Two processes in food can produce a brown colour. One is the enzymic oxidation of phenolic substances, such as occurs at the cut surface of an apple. The other is a reaction between proteins or amino acids and sugars, and is variously known as the Maillard reaction, the browning reaction and non-enzymic browning.

It takes place on heating or on prolonged storage and is one of the deteriorative processes that take place in stored foods. It is accompanied by a loss in nutritive value as the part of the protein that reacts with the sugar is the free amino part of the lysine. This complex is not digested and there is thus a reduction in the amount of lysine that is biologically available.

Manganese

An element that is considered probably a dietary essential as it is necessary to activate certain enzymes such as arginase and alkaline phosphatase, although no deficiency has ever been observed in man.

Essential for animals and deficiency causes perosis (slipped tendon) in chicks, sterility in rats and bone malformations in rabbits. Also essential for plants.

Green foodstuffs and tea are rich sources of manganese.

Marasmus, Nutritional

Severe wasting of the body of infants because of gross dietary deficiency, also called total undernutrition.

Symptoms include atrophy of muscles and subcutaneous fat, a wizened and shrivelled face, but, unlike kwashiorkor, no oedema

or fatty infiltration of liver.

Together with kwashiorkor marasmus is one of the major problems of infant nutrition in the developing countries, as infections such as measles and whooping cough are fatal to these subjects.

Menadione

See VITAMIN K.

Metabolic Water

Produced in the body by the oxidation of foods.

100 g of fat produce 107.1 g of water;

100 g of starch produce 55.1 g of water;

100 g of protein produce 41.3 g of water.

Methionine

An essential amino acid; one of the three containing sulphur; cystine, cysteine and methionine.

Cystine is non-essential but can replace part of the methionine of the diet, hence the sulphur amino acids are always considered together. They occupy an outstanding position in protein nutrition, as not only are sulphur amino acids the limiting factor in many proteins, but they are limiting in the total diet of most peoples that have been examined. In other words, the protein nutritive value of these diets can be improved either by adding more protein or more methionine (or cystine) but no other amino acid.

Methionine is available on the commercial scale and is added to animal feeds, where it is often, but not always, the limiting amino acid.

Chemically aminomethylthiol butyric acid.

Meulengracht Diet

For peptic ulcer patients, sieved foods such as meat, chicken, vegetables, at 2-hourly intervals. Differs from Sippy and Lenhartz diets (*which see*) in being much richer in protein.

The intention is to neutralize the acid in the stomach by the buffering effect of the protein.

Molybdenum

An element that is part of the enzyme xanthine oxidase and so may possibly be a dietary essential in small traces although there is no evidence for this. It is toxic in small doses and 'teart' in cattle is associated with feeding on pastures containing molybdenum.

It is essential to plants.

N.A.D.

Nicotinamide Adenine Dinucleotide—official name for COENZYME I, *which see.*

N.A.D.P.

Nicotinamide Adenine Dinucleotide Phosphate—official name for COENZYME II, *which see.*

Niacinamide

See NICOTINIC ACID.

Niacytin

The vitamin nicotinic acid occurs in some foods partly in a bound form as niacytin, which is not available to the body (nor to bacteria) until it has been hydrolysed.

It is a complex of nicotinic acid with glucose, xylose, arabinose and cinnamic acid derivatives.

Nicotinamide

See NICOTINIC ACID.

Nicotinamide-Adenine Dinucleotide

Officially accepted name for Coenzyme I.

Nicotinamide-Adenine Dinucleotide Phosphate

Officially accepted name for Coenzyme II.

Nicotinic Acid

Vitamin of the B complex with no numerical designation but sometimes called vitamin PP (pellagra-preventative). Known as

niacin in U.S.A. The amide, nicotinamide or niacinamide, is equally active and both forms are interchangeable. Functions in the body as a coenzyme in the oxidation of carbohydrates and is part of the molecules of Coenzymes I and II (NAD and NADP). Deficiency leads to the disease pellagra—mental disorder, intestinal disorders and a specific type of dermatitis. Pellagra occurs particularly among maize-eating people partly because maize is poor in available nicotinic acid and partly because it is deficient in the amino acid tryptophan, which can be converted into the vitamin in the body.

Nicotinic acid has been known since 1867 and was recognized as a vitamin in 1937. It is related to nicotine chemically but not in its biological effects. It is very stable to heat and losses in cooking and storage are small.

Requirements are related to the amount of carbohydrate oxidized, approx. 10 mg per day (60 mg tryptophan = 1 mg dietary nicotinic acid).

Found in liver, meat, yeast, cereal germ, added to flour in many countries.

Night Blindness or Nyctalopia

Inability to see in dim light through deficiency of vitamin A. Dark-adaptation test is used as an index of vitamin A deficiency as night blindness is the first symptom. *See* DARK ADAPTATION.

Nitrogen Balance

Condition in which nitrogen intake equals output, as in the normal adult. In negative balance the excretion exceeds the intake; positive balance is the reverse.

Growing children and convalescents are in positive nitrogen balance; patients with wasting diseases are in negative balance. Alternatively known as *nitrogen equilibrium.*

Non-esterified Fatty Acids

About 10 per cent of the total blood fatty acids, usually 0.5 to 1.0 micromole per litre, occur free or unesterified.

They have a rapid turnover rate and may be the primary fuel of working muscles. The fuel for sudden bursts of hard exercise is glycogen, but for long-continued work the free fatty acids are believed to be the source of energy.

Also known as unesterified fatty acids, or U.F.A. or N.E.F.A.

Nyctalopia

See NIGHT BLINDNESS.

Oedema

Excess fluid in the body indicated by pitting of the subcutaneous tissues when pressure is applied with the finger. May be caused by cardiac, renal or hepatic failure and by starvation *(famine oedema).*

Orotic Acid

Uracil-4-carboxylic acid; a growth factor for certain bacteria and other micro-organisms; appears to be a precursor of the pyrimidines.

Osteomalacia

Bone disorder in adults equivalent to rickets in children; due to shortage of vitamin D leading to inadequate absorption of calcium and loss of calcium from the bones.

Pantothenic Acid

A vitamin with no numerical designation; chemically *beta*-alanine plus pantoic acid. It is part of the structure of Coenzyme A, needed for the transfer of acetyl groups, and therefore essential for the metabolism of fats and carbohydrates.

Dietary shortage never arises; universally distributed in all living cells, best sources are liver, kidney, yeast, bees' royal jelly and fresh vegetables.

Deficiency symptoms in rats include greying of hair, dermatitis, adrenal damage; in chicks, dermatitis; in dogs, gastro-intestinal symptoms; but no definite pathological lesions in man.

Based on the needs of animals, human requirements would be 6 to 8 mg per day.

Also known as *Filtrate factor.*

Para-amino Benzoic Acid

Essential growth factor for micro-organisms and therefore classed as a vitamin. No deficiency symptoms have been observed

in higher animals except greying of the hair *(achromotrichia)* in rats.

It is part of the molecule of folic acid and it is assumed that one of the functions of p-amino benzoic acid is the formation of folic acid.

Sulphanilamide is chemically very similar and inhibits bacteria by blocking access to the vitamin.

Occurs in yeast, wheat, germ; smaller amounts in meat, liver, vegetables. Also called the anti-grey hair factor.

Pellagra

Disease due to deficiency of nicotinic acid. Symptoms include characteristic symmetrical dermatitis on exposed surfaces such as face and back of hands, mental disturbances and digestive disorders. (Student's mnemonic—dermatitis, dementia and diarrhoea—arsing from diet of meat, maize and molasses).

Phenylalanine

An essential amino acid. The non-essential tyrosine can partially replace phenylalanine in the diet.

It is rarely, if ever, the limiting amino acid in any food.

Inability to metabolize phenylalanine as an inherited disease and causes mental disorder, PHENYLKETONURIA, *which see.*

Phenylketonuria

Inherited metabolic defect wherein the essential amino acid, phenylalanine, is incompletely metabolized and the end-product, phenylpyruvic acid, is excreted in the urine. The by-products effect the brain and cause imbecility. The effect can be prevented by strict limitation of the phenylalanine intake.

Phosphate Bond, Energy-rich

Phosphates of organic compounds fall into two groups depending on the amount of energy released when the phosphate portion is hydrolysed. *(a)* Low energy potential, the ordinary phosphates that liberate 1.2 to 1.5 kcal (*e.g.*, phospho-sugars, phosphoglycerols, phosphoglyceric acids, phosphocholine); *(b)* high-energy potential, or energy rich phosphates, that liberate 8 to 10 kcal (*e.g.*, anhydrides, where phosphate is linked to phosphate,

acidic enols such as phosphoenolypyruvic acid, acetyl phosphate and nitrogen linked to phosphate).

Phosphate bond energy is the only form of energy that can be used by any living cell (muscular activity, osmotic work, the shock produced by the electric eel).

Adenosine triphosphate (ATP) is the key compound because it acts as a store of the energy-rich phosphate bonds.

Phosphorus

This element occurs in all biological tissues as phosphate, *i.e.*, salts of phosphoric acid. In the body most of it (80%) is present in the skeleton and teeth as calcium phosphate (Ca $(PO_4)P_2$), about 10 per cent in the muscles and 1 per cent in the nervous system. It is of vital importance in metabolism as many compounds (such as vitamins B_1, B_2, glucose, adenosine, etc.), function as phosphates.

The parathyroid glands control the level of phosphate in the blood.

Human dietary needs (about 1.3 g per day) are always met, as a deficiency never occurs in man. Phosphate deficiency, however, is one of the commonest deficiencies in livestock and gives rise to osteomalacia (also known as sweeny or creeping sickness).

Phosphate is also essential for plant growth, hence the use of bone meal as fertilizer. Bone meal (calcium phosphate) is often used as a supplement in human foods but as a source of calcium rather than phosphate.

In calculating the amount of phosphate in foodstuffs text-books vary in expressing the value as phosphorus (P) or phosphate (P_2O_5); 3 parts of P are equivalent to 142 parts of P_2O_5.

Phrynoderma

A follicular hyperkeratosis of the skin (blocked pores or toad-skin) often encountered in malnourished people. Originally thought to be due to vitamin A deficiency but possibly due to other deficiencies, and occurs mildly in well-nourished people.

Physin

Growth factor needed by rats and occurring in liver; probably vitamin B_{12}.

Phytic Acid

Inositol hexaphosphoric acid; present in the husk of cereals, dried peas and beans and some nuts.

The phosphate is insoluble and not digested. Part of the phytic acid may be present as the calcium salt (phytin) but this is also unavailable to the consumer. Moreover, phytic acid can combine with calcium and also iron from other foods in the diet and render them insoluble and unavailable. For this reason it has been held responsible for rickets and iron-deficiency anaemia among people eating large amounts of whole-grain cereals.

However, phytic acid is partially hydrolysed by the enzymes of yeast (*e.g.*, in bread baking) and that present in peas and beans is partially hydrolysed if these are soaked in water so the role of phytic acid in preventing the absorption of iron and calcium is not clear.

It is not present in highly milled cereals as it is contained in the outer branny layers.

Potassium

An element present in the body in considerable amounts, about 250 g, mostly inside the cells. It is not of dietary importance as there are adequate amounts in almost all foods.

It is essential in the body to maintain acid-base balance, the osmotic pressure and the irritability of nerves and muscle.

P.P. Factor

See NICOTINIC ACID.

Proline

A non-essential amino aid. Chemically pyrrolidine carboxylic acid.

Protein, Crude

Total nitrogen multiplied by the factor 6.25 (= 100 divided by 16). The nitrogen content of most purified proteins is 16 per cent and determination of crude protein, in effect, assumes that all the nitrogen present is protein. The error involved in this assumption is not usually large unless there is an abundance of purine nitrogen present.

For milk protein the factor is 6.38, for cereals 5.8.

Protein Efficiency Ratio

A measure of the nutritive value of proteins carried out on young growing animals. It is defined as the gain in weight per gram of protein eaten. The maximum values, e.g., egg protein, are about 4.4.

Zero values are obtained for those proteins which, when fed alone, do not permit growth, but may still have some limited value.

Protein Equivalent

A measure of the digestible nitrogen of an animal feeding stuff in terms of protein. It is measured by direct feeding or calculated from the digestible pure protein plus half the digestible non-protein nitrogen.

Protein Score

A chemical method of defining the nutritional value of proteins; the ratio of the amount of the limiting essential amino acid in the protein, to the target value. *See also* CHEMICAL SCORE.

Provitamin

A substance that is converted into a vitamin and may be consumed in its place, e.g., carotene is converted into vitamin A.

Pteroyl Glutamic Acid

See FOLIC ACID.

Pyridoxine

See VITAMIN B_6.

Pyruvate Oxidation Factor

See LIPOIC ACID.

Reference Man

An arbitrary physiological standard; defined as a man of 25 years, healthy, weight 65 kg, living in a temperate zone at a mean annual temperature of 10°C (50°F), assumed to require an average

daily intake of 3,200 kcal.

Reference Protein

A theoretical concept of the perfect protein which is used with 100 per cent efficiency at whatever level it is fed in the diet. Used as a means of expressing recommended intakes as grams reference protein per day.

The nearest approach to this theoretical protein is egg and human milk proteins which are used with 90 to 100 per cent efficiency when fed at low levels in the diet (4%) but not when fed at high levels (10 to 15%).

Reference Woman

An arbitrary physiological standard; defined as 25 years of age, 55 kg weight, engaged in general household duties or light industry, using 2,300 kcal per day, and, as reference man, living in a temperate zone at a mean annual temperature of 10°C (50°F).

Respiratory Quotient

Ratio of the volume of carbon dioxide produced when a substance is oxidized, to the volume of oxygen used.

In respiration in man the oxidation of carbohydrate results in R.Q. of 1.0; of fat, 0.71; and of protein, 0.8.

Retinal

Alternative name for vitamin A_1 aldehyde, also called retinene.

Retinene

Alternative name for vitamin A_1 aldehyde, also called retinal.

Retinoic Acid

Alternative name for vitamin A acid.

Retinol

Alternative name for vitamin A_1 alcohol. Vitamin A_2 alcohol is called 3-dehydro-retinol.

Rhizopterin

See FOLIC ACID.

Rhodopsin

Visual purple, *see* DARK ADAPTATION.

Riboflavine

See VITAMIN B_2.

Rice Diet

See KEMPNER DIET.

Rickets

Malformation of the bone in growing children due to shortage of vitamin D leading to poor absorption of calcium.

In adults the equivalent is osteomalacia.

Rickets, Refractory

Rickets that does not respond to normal doses of vitamin D but requires massive doses; it is suggested that refractory rickets is a congenital abnormality.

Rutin

A disaccharide (rhamnose and glucose) derivative of the flavone quercetin; found in grains, tomato stalk, elderberry blossom. *See* VITAMIN P.

Salt-free Diets

See SODIUM-FREE DIETS.

Scurvy

See VITAMIN C.

Serine

A non-essential amino acid; amino hydroxypropionic acid.

Siderophilin

Or *transferrin*, an iron-carbonate-protein complex, the form in which iron is transported in the blood plasma.

Siderosis

Accumulation of haemosiderin, an iron-protein complex, in the liver, spleen and bone marrow, in cases of excessive blood destruction, and on poor diet relatively rich in iron.

Said to be a common disorder among the Bantu people who cook their maize in iron pots and consume up to 100 mg of iron per day.

Sippy Diet

For peptic ulcer patients; hourly feeds of small quantities, 150 ml of milk, cream or other milky food. *See also* LENHARTZ DIET and MEULENGRACHT DIET.

SLR Factor

Streptococcus lactis factor—*See* FOLIC ACID.

Sodium

A dietary essential which is almost invariably satisfied by the normal diet. The body contains about 100 g of sodium and the average diet contains 3 to 6 g, equivalent to 10 g of sodium chloride. The intake varies considerably in different individuals and the urinary excretion varies accordingly.

There is a loss of salt in sweat and consequently excessive sweating can lead to excessive losses from the body. Extra dietary salt is required under such conditions.

Vegetables are relatively poor in sodium and rich in potassium; animal foods are rich in sodium.

Sodium-free Diets

Diets low in (never completely free from) sodium, but as most of the sodium of the diet is consumed as sodium chloride or salt, they are referred to as low-salt diets. It is the sodium and not the chloride that is of importance.

Sodium controls the retention of fluid in the body and reduced retention, aided by low-sodium diets, is required in cardiac insufficiency accompanied by oedema, in certain kidney diseases, toxaemias of pregnancy and hypertension.

The average sodium intake is 1,000 to 2,000 mg per day and

restricted diets usually about 500 mg and can be as low as 150 mg.

To improve the palatability of such diets 'salt' mixtures are available containing potassium and ammonium chlorides together with citrates, formates, phosphates, glutamates, as well as herbs and spices.

Foods low in salt (0 to 20 mg per 100 g); sugar, flour, fruit, green vegetables, macaroni, nuts; medium salt (50 to 100 mg per 100 g) chicken, fish, eggs, meat, milk; high salt (500 to 2,000 mg per 100 g) corned beef, bread, ham bacon, kippers, sausages, cheese.

Specific Dynamic Action

This is the name given to the increase in metabolism that follows the ingestion of foods. The extent of the increase varies with the food, for example when 1,000 kcal are fed as protein, the calorie expenditure increases to 1,300 kcal (30% increase), when carbohydrates and fats are fed the increase is 4 to 5 per cent. However, on a mixed diet the increase does not exceed 5 to 7 per cent.

The reason for specific dynamic action (SDA) is not known but it is suggested that it is partly the result of flooding the cells with metabolites and partly the heat of deamination of amino acids. In practice it means that 5 to 7 per cent should be added to calculated calorie requirements.

Spirometer, or Respirometer

Apparatus used to determine energy produced indirectly by calculation from the oxygen consumed.

In the Roth-Benedict type the subject breathes oxygen from a gasholder while the expired carbon dioxide is absorbed by soda-lime. The volume of oxygen used is recorded continuously. This spirometer is used clinically to measure metabolic rate in the diagnosis, for example, of thyroid disorder.

The Kofranyi-Micaelis respirometer is portable so that the energy used during active work can be measured.

Steroids

Compounds that contain the cyclopenteno-phenan threne ring system; they include vitamin D, male and female sex hormones,

hormones of the adrenal cortex, sterols such as cholesterol, toad poisons, cardiac glycosides of the digitalis group, and some of the carcinogenic hydrocarbons.

The steroid alcohols, *i.e.*, steroids carrying the OH alcoholic grouping, are sterols.

Sterols

Alcohols derived from the steroids include cholesterol, widely distributed in animal tissue including brain and egg yolk, coprosterol in faeces, ergosterol in yeast (which is the precursor for the synthetic vitamin D_2) and sitosterol and stigmasterol in plants.

Strepogenin

Name given to a peptide-like fraction from natural sources, claimed to be essential for micro-organisms and higher animals. The need for special peptides for the latter has not been confirmed.

Streptococcus Lactis Factor

A fermentation product of the mould *Rhizopus nigricans*, known as rhizopterin, which is essential to *S. lactis R.* Related to Folic Acid, *which see.*

Sulphur Amino Acids

Two amino acids, cystine and methionine, contain sulphur. As they are partly interchangeable they are classed together as the sulphur amino acids.

(Cysteine also contains sulphur but is of less importance).

Surface Area

Heat loss from the body, and therefore basal metabolism, are related to surface area. Calculated by formula of Du Bois or Meeh.

Du Bois: Area (sq cm) = weight (kg) to power of 0.425 x height (cm) to power of 0.725 x 71.84.

Meeh: Area = 11.9 x weight to power of 2/3.

Tachysterol

One of the compounds produced (along with vitamin D_2 or

calciferol) by ultra-violet irradiation of ergosterol. It has not anti-rachitic activity until it has been reduced to dihydrotachysterol, also called AT-10.

AT-10 is also used for the treatment of deficient thyroid function.

Thiamine

See VITAMIN B_1.

Thioctic Acid

Essential growth factor for various micro-organisms, now known as lipoic acid.

Threonine

An essential amino acid; the latest of the amino acids to be discovered (1935), amino hydroxybutyric acid.

Thyroglobulin

The protein-bound form in which thyroxine and triiodothyronine exist in the thyroid gland; it is broken down under the influence of the thyroid-stimulating hormones of the pituitary gland to liberate the free hormones which pass into the blood stream. Here they travel in combination with plasma protein as the so-called *protein-bound iodine* (PBI). The concentration of PBI in the blood is thus an index of thyroid activity.

Thyroid Gland

Endocrine gland situated in the neck; secretes four hormones, thyroxine (most abundant), diiodothyronine and two triiodothyronines.

Controls the basal metabolic rate of the body; when deficient (hypothyroidism) the metabolism is slowed down, when the activity of the gland is excessive (hyperthyroidism) there is an increased metabolic rate. Hence the use of thyroid extract as an aid to slimming.

Cretinism is a thyroid deficiency starting in childhood. A deficiency of iodine in the diet causes hyperplasia of the thyroid gland which is *goitre*.

Tocopherol

See VITAMIN E.

Transferrin

Or siderophilin, an iron-carbonate-protein complex, the form in which iron is transported in the blood plasma.

Triiodothyronine

The active hormone of the thyroid gland into which thyroxine is converted in the tissues. It is synthesized in the body from the amino acid tyrosine and iodine. *See* THYROID GLAND and THYROGLOBULIN.

Triphosphopyridine Nucleotide

See COENZYME II.

Tryptophan

Essential amino acid; rarely, if ever, limiting in any food. Chemically amino indole propionic acid.

Tuxford's Index

A formula for relating height to weight in children; heavier than average have an index greater than 1, lighter, have an index below 1.

$$\text{For boys} \quad \frac{W}{H} \times \frac{336-m}{270}$$

$$\text{For girls} \quad \frac{W}{H} \times \frac{308-m}{235}$$

W is weight in pounds, H is height in inches, m is age in months.

Tyrosine

A non-essential amino acid that has some sparing action on the essential amino acid phenylalanine. Not very soluble in water

and tends to crystallize out of solutions of protein hydrolysates.

Tyrosine is the starting material for the formation of melanin, the pigment in the hair and skin, increased after sunburn. Chemically, amino *para*-hydroxyphenyl propionic acid.

Tyrosinosis

Harmless inborn error of metabolism in which there is a blockage in the metabolism of tyrosine which is therefore excreted in the urine when tyrosine or phenylalanine is fed.

Valine

An essential amino acid, rarely, if ever, limiting in foods. Chemically, amino isovaleric acid.

Visual Purple

Or Rhodospire Pigment in the retina of the eye, consisting of vitamin A plus protein, necessary for vision in dim light. *See* DARK ADAPTATION.

Vitamers

Substances structurally related to vitamins, possessing some biological activity though often less than the true vitamin.

Vitamin A

Alternative name retinol. Essential for growth and maintains healthy condition of the moist epithelial tissues (lining mouth, respiratory and urinary tracts).

Its precise biochemical function is not known apart from the small proportion in the eye. Here vitamin A aldehyde (retinal or retinene) is combined with a protein to form visual purple, needed for vision in dim light.

Vitamin A deficiency leads to night blindness, xerophthalmia, stunting of growth, cornification of cells of the epithelial tissue. A deficiency of vitamin A is a major cause of blindness in undernourished countries.

Occurs abundantly in fish-liver oils (cod and halibut liver), and animal liver, and in dairy produce; it is added to margarine in most countries. Plant tissues contain carotene which is converted

into vitamin A in animals and man, and green vegetables are the major source of vitamin A in most diets. Red palm oil is very rich in carotene.

Daily requirements for adult 2,500 i.u.; 1 i.u. = 0.3 microgram of vitamin A alcohol.

Carotene is incompletely absorbed and the *alpha* and *gamma* forms have only half of the vitamin A activity of the *beta* form. Hence the daily requirement of vitamin A, if taken as carotene, is 7,500 i.u. As the average U.K. diet is 1/3 vitamin A: 2/3 carotene, the recommended intake is 5,000 i.u.

Vitamin A_2

Ordinary vitamin A found in mammals and salt-water fish is vitamin A_1; the liver of fresh-water fish contains mainly vitamin A_2, which differs only in having two fewer hydrogen atoms, and an extra double bond in the ring. Has 40 per cent of the biological activity of A_1.

Vitamin B Complex

See under individual B vitamins. These vitamins occur together in cereal germ, liver, yeast; are all coenzymes; and historically were discovered by separation from what was known originally as 'vitamin B': hence they are grouped together as the B complex. The 'Vitamin B_2 complex' is of purely historical origin and includes all except B_1.

Vitamin B_c

See Folic Acid.

Vitamin B_T

An essential dietary factor for the mealworm, *Tenebrio molitor*, and certain related species; now known to be identical with carnitine. In higher animals carnitine plays a part in fat synthesis by transferring acetyl across the mitochondrial membrane but it is not a dietary essential.

Vitamin B_1

Thiamine. Thiamine pyrophosphate is the coenzyme, cocarboxylase, needed in oxidative decarboxylation, *e.g.*, the

conversion of ketoglutarate to succinate and of pyruvic acid to acetyl. A deficiency of the vitamin leads to impaired metabolism of carbohydrate and clinically results in the disease beriberi in which pyruvate accumulates in the blood.

The daily requirement is related to the amount of carbohydrate oxidized (the non-fat calories)—0.6 mg per 1,000 non-fat calories of 0.4 mg per 1,000 total calories (daily total, approx. 1 mg). Thiamine is water-soluble and there is little storage in the body.

Occurs in cereal grains (little in white flour and white rice but these are enriched with added thiamine in many countries), in yeast, meat, especially pork, pulses, egg.

Obsolete name aneurine, official name thiamine.

It is one of the more labile of the vitamins and is destroyed by heat under alkaline conditions, by sulphur dioxide, and is lost by leaching into the cooking water. The baking of bread can lead to 15 to 30 per cent loss; up to half can be lost in cooked meat and fish, depending on the conditions.

Vitamin B_2

Riboflavine. In combination with a number of different proteins it forms a group of coenzymes called flavoproteins, essential for the oxidation of carbohydrates. Flavoproteins act as intermediary hydrogen carriers and include flavine mononucleotide, flavine adenine dinucleotide, cytochrome reductase, etc.

A deficiency of riboflavine impairs cell oxidation and results clinically in a set of symptoms known as ariboflavinosis. These include cracking of the skin at the corners of the mouth (angular stomatitis), fissuring of the lips (cheilosis) and tongue changes (glossitis); seborrheic accumulations appear around the nose and eyes.

Daily requirements are related to the amount of carbohydrate oxidized—0.6 mg per 1,000 kcal on an average of 1.5 mg per day. It occurs in yeast, liver, milk, eggs, cheese and pulses.

Processing losses are partly due to leaching into the water and partly to exposure to light. Fifty per cent of the riboflavine of milk can be destroyed in 2 hr by exposure to bright sunlight, and even on a dull day the losses can be 20 per cent. The products of photoxidation of vitamin B_2 destroy the vitamin C.

Vitamin B_6

Pyridoxine. Coenzyme of the enzyme transaminase, concerned with the metabolism of amino acids. Pyridoxamine and pyridoxal are equally biologically active.

It is essential to all species but does not appear to be lacking in human diets. Occasional deficiencies have arisen in infants, and the symptoms are increased irritability and convulsions. In experimental animals a deficiency leads to skin changes, microcytic anaemia and convulsions.

Pyridoxine occurs widely in foods particularly in cereals, liver, meat, yeast, milk and fish. There are no figures for the daily requirements but most diets provide 1 to 2 mg per day; babies are thought to need 0.2 to 0.3 mg per day.

Obsolete names are adermin, yeast eluate factor, factor 1 and factor Y.

Vitamin B_{12}

Essential for the formation of red blood cells. Active in relapse in pernicious anaemia in doses of 1 to 10 micrograms.

Although it is a dietary essential, cases of dietary deficiency have been observed only in individuals living solely on fruits and vegetables, so-called Vegans.

Pernicious anaemia is usually due to inability to absorb the vitamin, through lack of the 'intrinsic factor' normally present in the gastric mucosa and not to dietary inadequacy.

Functions as part of the mechanism in the synthesis of the nucleoproteins possibly also in methylation, and is a growth factor for bacteria and animals. Essential growth factors found in animal proteins and variously called the Animal Protein Factor, Cow Manure Factor and Zoopherin, are now thought to be effective because of their vitamin B_{12} content.

Occurs only in animal products, particularly in liver, also in kidney and meat; formed by bacterial synthesis; commercially produced by fermentation of 'Streptomyces.

Vitamin C

Or ascorbic acid; its precise biochemical function is unknown but it maintains the proper functioning of the cementing substances between the cells of the tissues.

When the vitamin is lacking, this substance breaks down and blood can seep from the blood capillaries under the skin and into the joints.

The total syndrome of vitamin C deficiency is scurvy, characterized by subcutaneous bleeding, weakness of the muscles, pains in the joints, soft spongy gums.

Ascorbic acid is rather unstable to air and heat, especially in alkaline solution, and is leached out into the water during cooking and wet processing.

Daily needs 20 mg according to British authorities, 70 mg according to American authorities.

Rich sources are fruits and vegetables. The vitamin is water-soluble and little is stored in the body. Also used as an antioxidant and bread improver. *See also* ERYTHORBIC ACID.

Vitamin D

Several substances have vitamin D activity, principally vitamin D_2 or calciferol (official name ergocalciferol) and vitamin D_3 or activated 7-dehydrocholesterol (official name cholecalciferol).

D_3 is formed naturally in the skin under the influence of sunlight; D_2 is synthesized commercially from ergosterol by ultra-violet irradiation.

Precise biochemical role unknown but aids the absorption of calcium from the intenstine and its deposition to form bone. Deficiency of vitamin D causes rickets in children and young animals; the adult equivalent is osteomalacia.

Vitamin D is not widely distributed in foods, main source is fish-liver oil, small amounts in egg yolk, butter, cheese; added to margarine, baby foods and evaporated milk, or alternatively the milk is irradiated.

Daily requirements 800 i.u., for babies, 400 i.u., for children, debatable whether adults require any at all or whether sufficient is synthesized from sunlight.

Massive doses up to 500,000 i.u., used in treatment of *lupus vulgaris* (tuberculosis of the skin). (1 mg calciferol = 40,000 i.u.)

Vitamin E

Fat-soluble vitamin essential for reproduction in animals but

not proved essential for man. Eight substances have vitamin-E activity, *alpha, beta, gamma* and *delta* tocopherols (methylated derivatives of tocol carrying a 16 carbon saturated isoprenoid side chain) and *alpha, beta, gamma* and *delta* tocotrienols (carrying unsaturated isoprenoid side chain).

Alpha-tocopherol is the commonest and is present in all plant tissues so far examined. The sources of vitamin E are plant seeds and their oils (*e.g.* wheat germ, soya, cottonseed and corn), eggs, liver, and legumes.

The tocopherols are potent antioxidants and their presence in vegetable oils protects against oxidative rancidity.

Vitamin E is connected with selenium (*see* Factor 3) as hepatic necrosis in rat, mouse and pig can be cured with either selenium compounds or vitamin E; muscular degeneration in sheep appears to be primarily due to selenium deficiency but can be ameliorated with either vitamin E or selenium.

Vitamin F

See Essential Fatty Acids.

Vitamin G

Obsolete name for vitamin B_2.

Vitamin H

See Biotin.

Vitamin K

Fat-soluble vitamin essential for the production by the liver of prothrombin (which is part of the blood-clotting system) and hence it is known as the anti-haemorrhagic vitamin.

It is widely distributed in greenstuffs and is normally synthesized by bacteria in the intestine and so no dietary deficiency has ever been demonstrated. Deficiencies occur only when there is a defect in fat absorption from the intestine, and vitamin K, being fat-soluble, is not absorbed. There may also be a deficiency in new-born infants who have a sterile intestinal tract.

Vitamin K occurs naturally in two forms, K_1 and K_2, which are derivatives of naphthoquinone. Other analogues have been synthesized, e.g., menadione (2-methyl-1: 4-naphthoquinone) and phthiocol (2-methyl-3-hydroxy derivative) which have greater

biological activity than the naturally-occurring vitamins and are used therapeutically.

Vitamin P

Name formerly given to a group of plant flavonoid substances which affect the strength of the walls of the blood capillaries, namely, rutin (in buckwheat), hesperidin, eriodictin and citrin (in the pith of citrus fruits). (Citrin is a mixture of hesperidin and eriodictin).

Called vitamin P from the German, 'permeabilitats vitamin'.

Now considered that the effect is pharmacological and that they are not dietary essentials, and therefore not classed as vitamins. Sometimes called 'bioflavonoids'.

Wetzel Grid

Children are grouped by physique into five groups, ranging from tall and thin to short and thick-set. A healthy child will grow, as measured by height and weight, along one of these channels at a standard rate, if he deviates from the channel malnutrition is suspected.

Xanthophyll

Yellow, hydroxy carotenoid pigment: occurs in all green leaves together with the chlorophyll and carotene, also present in egg yolk. Has no vitamin A activity.

Also known as lutein and luteol.

Xanthophylls

Collective term for hydroxylated carotenoids or carotenols.

Xerophthalmia

Occurs in advanced vitamin A deficiency. Epithelium of the cornea and conjunctiva of the eye deteriorates because of impairment of the tear glands, resulting in dryness then ulceration.

Zeaxanthin

Yellow, hydroxy carotenoid pigment found in maize, egg yolk, poultry fat and Physalis (chinese lantern flower); has no vitamin A activity.

Table 1
Composition of Food Per 100 Grams

Food	Water (g)	Protein (g)	Fat (g)	Available Carbohydrate (g)	Calories	Calcium (mg)	Iron (mg)	Vit A (iu)	Carotene (mg)	Vit D (iu)	Vit B_1 (mg)	Vit B_2 (mg)	Nicotinic acid (mg)	Vit C (mg)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cereal Foods														
Barley, pearl, raw	10.6	7.7	1.7	83.6	360	9.7	0.67	—	0	0	0.12	—	2.5	0
Barley, pearl, boiled	69.6	2.6	0.6	27.6	120	3.4	0.23	—	—	—	—	—	—	—
Biscuits, cream crackers	3.5	8.5	33.0	57.5	557	(96)	(1.48)	—	—	—	—	—	—	—
Biscuits, sweet, mixed	0.7	5.5	30.7	66.5	556	(83)	(1.20)	—	—	—	—	—	—	—
Bread, brown	37.7	8.7	2.1	49.9	242	(95)	2.44	—	0	0	0.21	—	2.5	0
Bread, white	38.3	7.8	1.4	52.7	243	(92)	(1.80)	—	0	0	0.18	—	1.7	0
Cornflakes, Kelloggs	8.0	6.6	0.8	88.2	367	7.4	2.80	—	—	—	—	—	—	—
Cornflour	12.5	0.5	0.7	92.0	354	15.3	1.43	—	—	—	—	—	—	—
Flour, English (100 per cent whole wheat)	15.0	8.9	2.2	73.4	333	35.5	3.05	—	0	0	0.40	0.16	5.0	0
Flour, English (70%)	15.0	7.9	1.0	81.9	349	18.9	1.40	—	—	—	—	—	—	—
Flour, Manitoba (100% whole wheat)	15.0	13.6	2.5	69.1	339	27.6	3.81	—	—	—	—	—	—	—
Flour, Manitoba (70%)	15.0	12.8	1.2	76.9	352	12.8	2.23	—	—	—	—	—	—	—

Macaroni, raw	12.4	10.7	2.0	79.2	360	26.3	1.43	—	0	0	0.14	—	2.0	0
Macaroni, boiled	72.2	3.4	0.6	25.2	114	8.1	0.45	—	—	—	—	—	—	—
Oatmeal, raw	8.9	12.1	8.7	72.8	404	55.3	4.12	—	0	0	0.50	0.10	1.0	0
Oatmeal porridge	89.1	1.4	0.9	8.2	45	6.3	0.47	—	0	0	0.05	0.01	0.10	—
Puffed wheat	7.8	13.9	2.0	75.3	358	35.3	3.29	—	—	—	—	—	—	—
Rice, polished, raw	11.7	6.2	1.0	86.8	361	3.7	0.45	—	0	0	0.08	0.03	1.5	0
Rice, polished, boiled	69.9	2.1	0.3	29.6	122	1.3	0.16	—	0	0	0.01	0.01	0.30	0
Rye (100%)	15.0	8.0	2.0	75.9	335	31.5	2.70	—	0	0	0.40	0.25	1.0	0
Rye (60%)	15.0	5.6	1.0	85.8	354	15.3	1.32	—	—	—	—	—	—	—
Shredded wheat	8.0	9.7	2.8	79.0	362	34.8	4.48	—	—	—	—	—	—	—
Soya, full fat flour	7.0	40.3	23.5	13.3	433	208.0	6.93	—	Tr	0	0.75	—	2.0	0
Spaghetti	12.4	9.9	1.0	84.0	365	22.6	1.21	—	—	—	—	—	—	—
Milk and Egg Products														
Butter, fresh	13.9	0.4	85.1	Tr	793	15	0.16	3,500	—	40	Tr	Tr	Tr	Tr
Cheese, Cheddar	37.0	25.4	34.5	Tr	425	810	0.57	1,400	—	14	0.04	0.50	0.1	0
Cheese, cream (home made)	10.0	3.3	86.0	Tr	8.13	30	0.14	3,500	—	35	Tr	0.20	Tr	0
Cream, single	71.9	2.4	21.2	3.2	219	79	0.31	700 (500)*	—	7 (3)*	0.03	0.12	0.07	1.2
Milk, fresh, whole	87.0	3.4	3.7	4.8	66	120	0.08	150 (100)*	—	1.5 (0.5)*	0.04	0.15	0.08	2.0
Milk, fresh, skimmed	90.2	3.5	0.2	5.1	35	124	0.08	Tr	—	Tr	0.04	0.16	0.08	1.5
Milk, condensed, whole, sweetened	20.3	8.2	12.0	56.0	354	344	0.17	350	—	3.5	0.10	0.40	0.20	3.0
Milk, condensed, whole, unsweetened	68.3	7.8	8.4	12.3	155	290	0.18	350	—	3.5	0.06	0.37	0.20	1.5

(Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Milk, dried, whole	1.3	27.0	29.7	38.8	530	960	0.64	1,200	—	12	0.28	1.2	0.70	10
Human milk	90.2	2.0	3.7	6.9	68	25	0.07	170	—	1.0	0.17	0.03	0.17	3.5
Eggs, fresh, whole	73.4	11.9	12.3	0	163	56	2.53	1,000	—	170	0.10	035	0.07	0
Eggs, dried	7.0	43.4	43.3	0	580	190	7.85	5,000	—	240	0.35	1.2	0.20	0
Eggs, fried	63.3	14.1	19.5	0	239	64	2.53	—	—	—	—	—	—	—
Meat Products														
Bacon, Danish Wilts, tank cured, raw	46.9	14.0	37.4	0	405	13.5	1.3	Bacon raw Tr	—	Tr	0.40	0.15	1.5	0
Bacon, English Wilts, dry cured, raw	36.3	12.5	49.3	0	509	13.5	0.9	—	—	—	—	—	—	—
Bacon, gammon, fried	24.9	31.3	33.9	0	444	24.9	2.8	Tr	—	Tr	0.40	0.15	1.5	0
Beef, corned, canned	58.5	22.3	15.0	0	231	12.8	9.8	Tr	—	Tr	Tr	0.20	3.5	0
Beef, silverside, boiled	46.2	28.0	20.0	0	301	23.3	3.7	—	—	—	—	—	—	—
Beef sirloin, roast	45.2	21.3	32.1	0	385	5.8	4.6	Tr	—	Tr	0.05	0.22	5	0
Beef steak, raw	68.3	19.3	10.5	0	177	5.4	4.3	Tr	—	Tr	0.07	0.20	5	0
Beef steak, fried	56.9	20.4	20.4	0	273	5.2	6.0	Tr	—	Tr	0.08	0.25	5.5	0
Beef steak, stewed	58.1	30.8	8.6	0	206	3.0	5.1	Tr	—	Tr	0.05	0.22	5	0
Chicken, breast, raw	73.7	23.2	2.1	0	115	5.8	0.7	Tr	—	Tr	0.10	0.07	10	0
Chiken, boiled	61.0	26.2	10.3	0	203	10.7	2.1	—	—	—	—	—	—	—
Duck, roast	52.0	22.8	23.6	0	313	19.0	5.8	—	—	—	—	—	—	—
Ham, boiled	48.6	16.3	39.6	0	435	12.7	2.5	Tr	—	Tr	0.50	0.20	3.5	0
Liver, ox, raw	73.3	16.5	8.1	0	143	8.4	13.9	20,000	—	45	0.30	3.0	13	30

Liver, ox, rolled in flour and fried	47.7	29.5	15.9	4.0	284	8.6	20.7	as raw	—	as raw	0.30	3.5	15	20
Mutton chop, grilled, lean only	53.7	26.5	17.5	0	271	20.9	30.0	Tr	—	Tr	0.10	0.25	4.5	0
Pork leg, roast	49.7	24.6	23.2	0	317	5.2	1.7	Tr	—	Tr	0.80	0.20	5	0
Sausage, beef, fried	49.2	13.8	18.4	15.7	287	21.2	4.1	—	—	—	—	—	—	—
Fish														
Cod, steamed	79.2	18.0	0.9	0	82	14.6	0.5	—	—	—	—	—	—	—
Cod, fried	69.4	20.7	4.7	2.9	140	49.6	1.0	—	—	—	—	—	—	—
Crab, boiled	72.5	19.2	5.2	0	127	29.4	1.3	Tr	—	0	0.10	0.15	2.5	Tr
Haddock, steamed	75.1	22.0	0.8	0	97	54.6	0.7	—	—	—	—	—	—	—
Haddock, fried with batter	65.1	20.4	8.3	3.6	175	114.0	1.2	—	—	—	—	—	—	—
Herring, raw	63.5	16.7	18.1	0	273	101.0	1.5	150	—	900	0.03	0.30	3.5	Tr
Herring, fried	58.7	21.8	15.1	1.5	235	38.6	1.9	—	—	—	—	—	—	—
Salmon, canned	69.9	19.7	6.0	0	137	66.4	1.3	300	—	500	0.03	0.10	7	Tr
Sardines, canned	50.7	20.4	22.6	0	294	409.0	4.0	100	—	300	Tr	0.20	5	Tr
Fruit														
Apples, English eating, raw	84.5	0.3	Tr	11.7	45	3.5	0.29	—	0.03	0	0.04	0.02	0.1	5
Apples, stewed without sugar	88.9	0.2	Tr	7.4	28	2.8	0.22	—	0.02	0	0.03	0.01	0.1	3
Apricots, raw	86.6	0.6	Tr	6.7	28	17.2	0.37	—	1.5	0	0.04	0.05	—	7
Bananas	41.6	1.1	Tr	19.2	77	6.8	0.41	—	0.20	0	0.04	0.7	0.6	10
Blackberries, raw	82.0	1.3	Tr	6.4	30	63.3	0.85	—	0.10	0	0.03	0.04	0.4	20
Dates, dried	14.6	2.0	Tr	63.9	248	67.9	1.61	—	0.05	0	0.07	0.04	2.0	0
Grapefruit	90.7	0.6	Tr	5.3	22	17.1	0.26	—	Tr	0	0.05	0.02	0.2	40
Melons, yellow	94.2	0.6	Tr	5.0	21	13.8	0.24	—	2.0	0	0.05	—	0.5	25

(*Contd.*)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Oranges	86.1	0.8	Tr	8.5	35	41.3	0.33	—	0.05	0	0.10	0.03	0.2	50
Peaches, raw	86.2	0.6	Tr	9.1	37	4.8	0.38	—	0.50	0	0.02	0.05	1.0	8
Peaches, canned	80.0	0.4	Tr	17.2	66	3.5	1.93	—	0.25	0	0.01	0.02	0.6	4
Pears, raw	83.4	0.2	Tr	10.4	240	6.9	0.22	—	0.01	0	0.03	0.03	0.2	3
Raisins, dried	21.5	1.1	Tr	64.4	247	60.6	1.55	—	Tr	0	0.10	—	0.5	0
Nuts														
Almonds	4.7	20.5	53.5	4.3	598	247	4.23	—	0	0	—	—	2.0	Tr
Barcelona nuts	5.7	12.9	64.0	5.2	667	170	2.97	—	0	0	0.11	—	—	Tr
Brazil nuts	8.5	13.8	61.5	4.1	644	176	2.82	—	0	0	1.00	—	—	Tr
Chestnuts	51.7	2.3	2.7	36.6	172	46	0.89	—	0	0	0.20	—	0.20	Tr
Coconut, fresh	42.0	3.8	36.0	3.7	365	13	2.08	—	0	0	0.03	0.02	0.30	Tr
Peanuts	4.5	28.1	49.0	8.6	603	61	2.04	—	0	0	0.90	0.10	16	Tr
Vegetables														
Beans, broad, boiled	83.7	4.1	Tr	7.1	43	21.2	0.98	—	—	0	—	0.04	3.0	15
Beans, butter, raw	11.6	19.2	Tr	49.8	266	84.8	5.92	—	0	0	0.45	0.13	2.5	
Beans, butter, boiled	70.5	7.1	Tr	17.1	93	18.7	1.67	—	—	—	—	—	—	—
Beans, French, boiled	95.5	0.8	Tr	1.1	7	38.6	0.59	—	0.5	0	0.04	0.07	0.3	5
Beans, haricot, raw	11.3	21.4	Tr	45.5	258	180.0	6.65	—	0	0	0.45	0.13	2.5	0
Beans, haricot, boiled	69.6	6.6	Tr	16.6	89	64.5	2.50	—	—	—	—	—	—	—
Beetroot, raw	87.1	1.3	Tr	6.0	28	24.9	0.37	—	Tr	0	0.03	0.05	0.1	6
Brussels sprouts, raw	84.3	3.6	Tr	4.6	32	28.7	0.66	—	0.4	0	0.10	—	0.7	100
Brussels sprouts, boiled	90.8	2.4	Tr	1.7	16	27.1	0.63	—	0.4	0	0.06	—	0.4	35

Cabbage, winter, raw	90.6	2.7	Tr	3.8	25	72.3	1.23	—	0.3	0	0.06	0.05	0.25	60
Cabbage, winter, boiled	95.9	0.8	Tr	1.3	8	58.2	0.47	—	0.3	0	0.03	0.03	0.15	20
Carrots, old, boiled	91.5	0.6	Tr	4.3	19	36.9	0.37	—	12.0	0	0.05	0.04	0.4	4
Carrots, young, boiled	81.1	0.9	Tr	4.5	21	28.8	0.43	—	6.0	0	0.05	0.04	0.4	4
Carrots, canned	91.2	0.7	Tr	4.4	19	26.6	1.28	—	7.0	0	0.04	0.02	0.3	3
Cauliflower, raw	89.1	3.4	Tr	2.8	25	18.1	0.58	—	0.03	0	0.10	0.10	0.6	70
Cauliflower, boiled	94.9	1.5	Tr	1.2	11	23.0	0.48	—	0.03	0	0.06	0.06	0.4	20
Peas, fresh, raw	78.5	5.8	Tr	10.6	64	15.1	1.88	—	0.30	0	0.32	0.15	2.5	25
Peas, fresh, boiled	80.0	5.0	Tr	7.7	49	12.6	1.22	—	0.30	0	0.25	0.11	1.5	15
Potatoes, old, raw	75.8	2.1	Tr	20.8	87	7.7	0.75	—	Tr	0	0.11	0.04	1.2	10-30 mg**
Potatoes, old, boiled	80.5	1.4	Tr	19.7	80	4.3	0.48	—	Tr	0	0.08	0.03	0.8	50-70 %***
Potatoes, old, 'chips'	47 0	3.8	9.0	37.3	239	13.8	1.35	—	Tr	0	0.10	0.04	1.2	65-75 %***
Potatoes, new, boiled	78.8	1.6	Tr	18.3	75	5.0	0.46	—	—	—	—	—	—	—
Tomatoes, raw	93.4	0.9	Tr	2.8	14	13.3	0.43	—	0.7	0	0.06	0.04	0.6	20

* Summer (winter).
** Depending on storage time.
*** Of raw value.

Composition refers to *edible portion* of food unless otherwise stated, *e.g.*, fruit excluding, skin fish and meat excluding bones.
From 'The Composition of Foods' by R.A. McCance and E.M. Widdowson. Medical Research Council Special Report Series No. 297. H.M.S.O. *(By permission.)*

Appendix 'B'

A Glossary of Food Storage, Refrigeration and Handling

Absorption Systems

Where a supply of cheap cooling water and steam or other heat source is available, the closed absorption system of refrigeration, like the steam jet or vacuum system, compares favourably with mechanical refrigeration. Two systems are employed, one using a refrigerant-solid adsorbent combination and the other a refrigerant-liquid absorbent combination. With both, heat is applied to cause a distillation process. If the system uses a solid adsorbent, the problem of distillation is simple and it is only necessary to volatilize the refrigerant in one vessel and condense the resulting vapour in another. Operation is, however, intermittent. After heating, the solid material must be cooled before it will again act as an adsorbent.

The process of distillation with a refrigerant-liquid absorbent combination is much more complex and additional plant is required. Operation can, however, be made continuous by means of a liquid pump, or alternatively, with the aid of an inert gas, circulation may be made possible by means of a percolator action as well as by the reduction of the density on account of the temperature rise due to heating. Raoult's Law is involved, but in order to make an effective absorption machine, large negative deviations from the Law must be shown by solutions of the refrigerant in the liquid absorbent, because the larger the negative deviation, the greater is the amount of refrigerant that can be cycled, using a given weight of absorbent. Cycling a large amount of refrigerant for a given weight of absorbent is important because

of the heat required to raise the temperature of the mixture and dissociate the refrigerant and the absorbent. Only the latent heat can be recovered as useful work.

Commonly used refrigerant-absorbent combinations are *(a)* ammonia and water and *(b)* monofluorodichloromethane (F11) and dimethyl other of tetracthylene glycol. Preference is given to the former, for which a number of parts are necessary for the distillation and absorption of ammonia gas after it is expanded and return it to the liquid anhydrous state at high pressure, ready to be again expanded. These include (1) a generator, usually heated by live or exhaust steam, (2) analyser, (3) rectifier, (4) condenser, (5) receiver, (6) expansion valve, (7) evaporator, (8) absorber, (9) ammonia pump and (10) heat exchanger. In the case of combination (b), the boiling point of the refrigerant and absorbent are sufficiently wide apart that almost pure refrigerant is obtained without the use of a rectifier.

The action of heat applied to the generator is to cause a distillation process where, in the case of ammonia-water combinations, both water vapour and superheated ammonia gas pass out of the generator into the analyser and rectifier. Here the mixture is cooled to within –7 or –12°C (20 or 10°F) of the liquefaction temperature of the refrigerant with the condensation of water vapour and the incidental absorption of ammonia. The condensed water vapour is returned to the generator and the refrigerant and absorbent mixture (the mixture still has approximately 0.2 per cent by weight of water vapour present) passes to the condenser, where it is liquefied by means of condensing water. It passes to the receiver and thence through an expansion valve to an evaporator, where heat is absorbed from a cooling load.

From the evaporator the ammonia gas, and residual absorbent, passes to the absorber where it unites with cool absorbent from the generator which is initially low in refrigerant concentration. The resulting cold strong liquor is then pumped from the bottom of the absorber through the heat exchanger, where it cools the hot weak liquor coming from the generator and is itself heated. It then passes on through the analyser, where it tends to cool the distillate being boiled off from the generator, back into the generator; to repeat the operating cycle. The pressure in the generator is sufficient to force the weak liquor, from which the gas has been driven out

of the generator, through the heat exchanger and then into the absorber. The heat produced by the absorption of ammonia in the absorber is removed by water cooling.

Air Agitation

Air agitation is now almost universally employed in the production of clear transparent ice from ordinary untreated water. There are two principal systems, differing in that the air used is employed at a high or low pressure. In the low-pressure system the air is delivered at a pressure of from 2 to 3 psi by a pipe system arranged over the ice tank. Each ice can or mould has a drop-pipe, connected to the headers, extending the greater part of the depth of the mould. The agitation of the water during freezing prevents the opacity due to imprisoned air bubbles and largely concentrates any salts or suspended matter in the central core of the block. In the high-pressure system the air is introduced at a pressure of 15 to 30 psi, and usually cooled to as low a temperature as possible to remove its water vapour content. Air is obtained from an ordinary reciprocating compressor and cooled by either dry, direct expansion or the wet brine contact system. The advantages claimed for the high-pressure system are that, as agitation can be continued until the block is completely frozen, clearer ice is obtained and that, as the air is introduced from the bottom of the mould, the labour in removing drop-pipes is avoided.

Air Blast Freezers

This type of plant is the most universally employed in freezing work and is applied to anything from carcase meat to peas. They can be of the batch type, semicontinuous or of the fully automatic type giving continuous production. Produce is usually processed in freezers of the batch type on shelves or wheeled trucks provided with a shelved superstructure constructed to permit easy passage of the freezing air around the produce. Freezers incorporating semi-continuous and continuous features are in effect freezing tunnels, through which the produce is transported by overhead or wire mesh belt conyeyor, or any other means of conveyance most suited to the produce, counter-current or right-angles to the flow of freezing air. The refrigerated pipe batteries and fans providing for the freezing air blast are usually external to the freezer structure.

Air Conditioning

The practice of air conditioning has for its objective the simultaneous control of all or some of those factors affecting the physical or chemical conditions of the atmosphere within any structure, these including temperature, humidity, motion, distribution, dust, bacteria, odours and toxic gases. Application is to produce desired effects on the occupants of the structure and/or upon materials stored or handled in it. The controlled environmental conditions may be necessary to promote worker health and efficiency; facilitate, or even make possible, a process; provide for the safe-keeping of specified materials and products; prevent, in certain circumstances, the precipitation of moisture on the surface of processed goods; prevent moisture regain by hygroscopic materials.

The most desirable atmospheric conditions during food processing depend upon the product and the nature of the process. As far as the behaviour of the material itself and its desired final condition is concerned, each material and process presents a different problem. The best relative humidities may range up to 100 per cent. Similarly the most desirable temperature may range between wide limits for different materials and treatments. Extremes in either relative humidity or temperature may require relatively expensive equipment for maintaining these conditions automatically.

Furthermore, comfort and productive efficiency must be considered and often a compromise between the optimum conditions for processing and those required for the comfort of the worker are desirable. Generally, relative humidities below 40 per cent are considered to be on the dry side, conducive to low regains, brittle conditions of fibrous materials, prevalence of static electricity and a tendency towards dryness of the skin and membranes of human beings. At the other end of the scale, humidities above 80 per cent are relatively damp, conducive to high regains, extreme softness and pliability.

Common applications are to the control of the rate of biochemical reactions, crystallization and regain; also prevention of the precipitation of moisture. An example of the first is to be seen in the dough room of any modern bakery. Yeast develops best at a temperature of 26.7°C (80°F), whilst a relative humidity of 65 per cent is maintained to hold the surface of the dough open to

allow the CO_2 gases formed by the fermentation to pass through and produce a loaf of bread, when baked, of even, fine texture without large voids. Another example is found in the curing of macaroni. The flour and water mixture is fermented and dried. As it is necessary to have a definite amount of water present to carry on a fermentation process, the moisture must be removed in a relatively short period to stop fermentation and prevent souring and in such a manner as to avoid setting up internal strains in the mixture. Best results are obtained with the correct cycles of both temperature and humidity.

Equally important is the use of air conditioning in controlling rates of crystallization, as in the sugar coating of gums and nuts; by the addition of a heavy sugar solution to the tumbling mass in coating pans. Temperature controls the rate of cooling, whilst the relative humidity, through evaporation, changes the density of the solution. If the cooling and drying is too slow, the coating will be rough and semi-translucent; if too fast, the coating will chip through to the interior. Control of the rate of regain applies to such products as macaroni, crackers, starch and gelatin. The regain of crackers, for example, rises from 2.8 to 10.9 per cent when in equilibrium at a dry bulb temperature of 24°C (75°F) and 20 to 80 per cent R.H. respectively. On the other hand, a fairly high humidity is required to prevent moisture loss, and in consequence, weight, during the cooling and storing of bread and cakes.

The relative humidity of the air in any given space at known dry-bulb temperature can be governed by control of the absolute humidity. Precipitation of moisture occurs when the temperature of any given air-water vapour mixture is reduced to below the dew-point. The latter is particularly important when processing artificially cooled material. For example, air at 21.1°C (70°F) and 50 per cent R.H. has a dew-point temperature of approximately 10°C (50°F). If dried to give conditions of 21.1°C (70°F) and 25 per cent R.H., the dew-point will be reduced to approximately 1.1°C (34°F). Hence, assuming a material to be cooled to between 1.7 to 2.2°C (35 to 36°F), precipitation of moisture on its surface would occur with air in the former condition and none with the latter.

The foregoing indicates that many phases of food processing require the use of air controlled as to temperature and humidity, the latter incurring either dehumidification or humidificaton. One method, most generally used, of maintaining humidities lower

than ambient is, as stated, to remove water vapour by cooling the air to below the dew-point temperature, the final moisture content being controlled by the degree of sub-cooling applied. For the example quoted, *i.e.*, 21.1°C (70°F), and 50 per cent R.H., precipitation commences at a temperature of 10°C (50°F) and continues downwards to a temperature of 1.1°C (34°F), during which period 55–29=26 grains of moisture per lb of air are removed. The dry-bulb temperature of the theoretically saturated air is then raised by heating to give the desired working conditions. Alternatively, resort may, in some cases, be had to the use of solid adsorbents; which remove moisture by virtue of their physical structure. Activated alumina and silica are the most widely employed substances. Humidification may be effected by the process of adiabatic saturation, or directly by spray or atomization; as in textile processing.

Air Washers

Air washers may be used as either humidifiers or dehumidifiers, depending upon the method of their operation and the temperature of the spray water. Air humidification is effected by the vaporization of water which always requires heat from some source. This heat may by added to the water prior to the time vaporization occurs or it may be secured by a transformation of sensible heat of the air humidified to latent heat as vapour is added to the air. Dehumidification consists of the removal of moisture from the air and may or may not involve the removal of heat from the air-vapour mixture. With spray equipment dehumidification of air necessitates the removal of heat.

Construction of an air washer consists essentially of a chamber through which air, after filtration, passes and comes into intimate contact with water. Provision may be made for treating all fresh air, or fresh and recirculated air to conserve heating or cooling load. Contact between the air and washer water is secured by *(a)* breaking the water into a very fine mist, *(b)* passing the air over surfaces which are continuously wetted water or *(c)* a combination of water sprays and wetted plates. Thus, a conventional air washer has one or more banks of water sprays forming a fine mist; or banks of water sprays and capillary cells, sometimes followed by a series of zig-zag plates known as scrubber plates, over which a stream of water is maintained; followed again by eliminator plates

designed to catch the free moisture entrained in the air stream and return it to a sump at the base of the washer for re-use.

Moisture removal from an air-vapour mixture can be accomplished in an air washer so long as the temperature of the spray medium is less than the dew-point of the air passing through the unit. Both sensible and latent heat are removed in the process of dehumidification by cooling. Abstraction of sensible heat occurs during the entire time the air is in contact with the spray medium. Latent heat removal takes place as condensation occurs. Therefore, the lower the spray temperature the greater the amount of moisture removal per lb of dry air, all other conditions remaining the same. Air washers using refrigerated spray media generally have their own recirculating pumps. These deliver to the washer sprays a mixture of water from the washer sump, which has not been re-cooled, and refrigerated water. The quantities of each of the portions of the spray medium are controlled by a mixing valve activated by a dew-point thermostat located in the washer air outlet.

Surface Cooling Coils

For combined cooling and dehumidification, surface coils present an alternative to spray dehumidifiers. They may also be housed in the same chamber as similar coils and water sprays or steam jets providing for heating and humidification. Selection between spray and surface humidifiers is based on consideration of the advantages offered by each. A spray humidifier is usually designed to deliver saturated or nearly saturated air and this tends to simplify the control problem, *i.e.*, the dry-bulb temperature is also the dew-point and hence a dew-point control can be arranged by using a simple duct thermostat. Spray dehumidifiers also have the advantage over unwetted coils of a certain degree of air cleaning and odour absorption. On the other hand, coils make possible a closed and balanced cooling circuit, eliminating the unbalanced pumping head and the complication of water level control incidental to multiple spray dehumidifiers. Another advantage is that the surface coil system can by used with direct expansion of refrigerant; providing for lower initial and operating costs; also lower temperatures.

Solid Adsorbents

Activated alumina and silica gel are the most widely used solid adsorbents, both substances being characterized by a physical structure containing a great number of extremely small pores but still retaining sufficient mechanical strength to resist whatever wear or handling to which they are subject. Adsorbed water is held on their extensive surface by physical forces rather than chemical ones. No change in volume, structure or appearance takes place, although the full percentage of water may have been picked up. Also, after their moisture removal efficiency has dropped below the desired value, the adsorbed water may be driven off by heat so that, after cooling, the adsorbent is again ready for use. This cycle of adsorption and regeneration, or re-activation, may be repeated indefinitely with little or no deterioration.

Substantially complete 100 per cent removal of moisture from air is achieved until activated alumina has adsorbed up to 14 per cent of its own weight. It will, however, continue to adsorb moisture at a lesser level of efficiency until the water content has reached 40 per cent of its weight. Good drying efficiency is maintained by silica gel when it has adsorbed up to over 20 per cent of its own weight of water. Both may be reactivated by heating direct or by a stream of hot air. In the grade of alumina frequently used for air drying reactivation may by accomplished at temperatures up to 176.7°C (350°F) whilst in the case of silica gel temperatures up to 260°C (500°F) are frequently employed. Cooling of the re-activated adsorbent is necessary before being replaced in service; efficiency decreases as the desiccant temperature rises above the allowable maximum. It may also, in certain instances, be necessary to cool the desiccant or pre-cool the air to a temperature sufficient to prevent objectionable temperature rise due to heat of adsorption.

For continuous drying, two types of system are in common use; the moving and stationary bed. The former are generally used for applications needing only moderate degrees of dryness, *i.e.*, up to 30 to 40 per cent R.H., or even more. For these it is more economical to build equipment using a small quantity of desiccant in a rapid cycle with high flow rates and low contact times. The equipment thus consists of continuous and automatic machines with shallow beds of desiccant to reduce pressure losses to a

minimum. The chamber containing the moving or rotary bed is divided into two, sealing on the bed being maintained by flaps but also being dependent to a large extent on the maintenance of a low static pressure-difference between the two divisions. Since the processes of adsorption, heating and cooling are carried out continuously, a steady outlet humidity is obtained with steady inlet conditions.

The stationary bed system incorporates a number of stationary trays or beds of desiccant—usually 2 or 4—to which the air flows are directed by a rotating valve system. The directions of the adsorbing and heating air flows are controlled by two specially constructed valves, the ports of which are so arranged that a small quantity of air can be employed partially to cool the heated adsorbent before it is used for drying. The re-activation air is discharged to waste.

The stationary beds also incorporate cooling coils, if necessary, to help maintain isothermal conditions and, if required, the dry air can be passed through a cooler to remove the heat generated by the adsorption action. In addition, humidity control is usually provided by a parchment type element, or similar, giving on/off proportional control, according to the size and complexity of the duty required.

Air Washer

See Air Conditioning.

Ammonia

See Refrigerants.

Apron Conveyors

See Chain Conveyors; Bulk Conveying.

Attachments

See Powered Trucks.

Automatic Control

Contactor Starters

Electric-driven machinery can be controlled by automatic starters. These are usually of the contactor type for the higher starting load, 1 h.p. and up, but may be direct-on type where the

starting load is low enough to fall within the limits set by the local supply authorities. Either type is suitable for direct current, or for alternating, but direct-on starting switches, thermal relays, and the like will operate higher starting currents on A.C. than D.C.

Pressure-controlled switches—The force exerted by an expanding bellows or the straightening effect of a bourdon tube is made to press together electrical contacts.

Temperature-controlled switches—Many of these are operated by the expansion of a volatile liquid contained in a bulb and attached by capillary tube to an expanding bellows which in turn operates a switch. Other types use bi-metal strips, coils or rods; in these two metals whose thermal expansion is different are brazed together.

Automatic Expansion Valves

A wide range of designs is available for controlling automatically the amount of liquid refrigerant passing from the condenser or liquid receiver to the evaporator. The valve may be controlled by liquid level by means of a ball valve or displacement float, by pressure control operating through a bellows or a flexible diaphragm, by temperature control in which the temperature bulb may be located in the suction line, the evaporator or the cold chamber, or by purely mechanical means such as a lever system or by spring loading.

Adjustment is usually provided for setting the control unit within the temperature or pressure range of the particular instrument and /or adjusting the differential, *i.e.*, the temperature difference between the point at which it cuts out and cuts in again. Too small a differential may give rise to undue sensitivity, a tendency to hunt and excessive wear and tear of the starting gear. Too large a differential may cause uneconomical running and damage to stored goods due to wide fluctuations of temperature.

Belt Conveyors

A solid sustaining surface is provided for a wide variety of materials, both bulk and packaged items, by various types of belt conveyors. These consist essentially of a carrying belt, intermediate supports for the belt, pulleys, take-ups, guides and a means of driving the belt. They are made level, inclined, declined or as a

combination of these features and with flexible steel, stitched canvas, solid woven, rubber-covered duck, steel mat or wire mesh belts. Inclined conveyors with trough top belts operate up to 28° slopes and should have a flat or slightly inclined feeding section for any slope over 15°. The intermediate supports for the belt are usually tread, or load-carrying rollers fitted, with ball, roller, bronze or oil-impregnated bearings, into side-frames, or they may be slide beds made of wood or sheet metal. The idlers that support the returning side of the belt are of the roller type, as their use reduces belt friction and wear to a minimum. Spacing of the intermediate roller varies, according to the nature of the load, from 4 in upwards on the carrying surface and from 6 to 10 ft on the return side. Alternatively, if both strands of the band are used for conveying, sufficient supporting rollers are used on both upper and lower strands to carry the load imposed upon it.

The type of conveyor drive varies with its speed and the amount of power required, whilst the efficiency at which power is transmitted from the terminal driving pulley to the belt depends on the traction between pulley and belt, and varies with the diameter of the pulley and the arc of contact between their surfaces. To increase the efficiency, pulleys may be lagged by riveting rubber on the face, or cementing on asbestos fabric. There are in use five common types of drive: (1) plain pulley; (2) snubbed pulley; (3) double-snubbed pulley; (4) tandem and (5) press roller.

The plain pulley drive has an arc of contact between 135 and 180°, and is satisfactory for simple conveyor layouts where the belt is short and loads are light. The snubbed pulley drive increases the arc of contact from 180 to 245° and can transmit 15 per cent more power than can the plain pulley drive. The double-snubbed pulley drive provides an arc of contact up to 270°, and is most suitable for the heavier installations. The tandem drive utilizes two drive pulleys, provides a total arc of contact up to 450° and is needed only for those installations where other types of drives cannot produce enough traction. The press roller drive, employed for oven and similar installations has the drive pulley at the feed end of the conveyor rather than at the discharge. This arrangement pulls from the cold return, thus relieving tension on the carrying surface in order that there may be a minimum strain on the belt as it passes through the heated chamber. Auxiliary press rollers are arranged to maintain a 180° arc of contact between belt and

drive pulley.

All the foregoing drives, except the press roller type, pull the carrying surface of the belt, thus maintaining tension in the side. To adjust the tension in the slack side, a belt take-up of either the screw or counter-weight type is placed close to the drive pulley. Screw take-ups are simple, inexpensive and satisfactory for small conveyors, whereas counterweight take-ups are more satisfactory for long conveyors as they automatically maintain a constant predetermined tension under all conditions of load, changes in temperature and stretching of the belt.

Normally, the take-up adjustment on a belt conveyor is estimated at 1 per cent of the length of the conveyor; in other words, a 40 ft long conveyor should have an adjustment of 0.4 ft or 3.6 in. In the case of a tandem drive, practically no adjustment is required, although it is good practice to provide a few inches at each end for training the belt. Belt conveyors over 200 ft long, or those subjected to wide changes in temperature and humidity, etc., should have automatic or gravity type take-ups.

The maximum recommended incline for flat-top belt conveyors receiving from gravity is given at 10° for plain cotton or stitched canvas belts, and 12° with rubber filled or crepe-top belts. With the use of three-pulley devices, or other means of starting the article up the incline, the maximum incline for satisfactory conveying without undue slip is 12° for plain cotton or stitched canvas, 15° for rubber filled belts and 25° for crepe-top. Tread rollers should be spaced closer on the steeper inclines, especially with heavier articles. At least two rollers under the article being conveyed are necessary. It should be noted that the same forces act on a decline belt. However, the motor in this case must resist the forces and this requires practically the same horse-power as the incline belt.

In general, the main characteristics of a belt conveyor are (1) top and return runs of belt may be utilized, (2) it will operate on level, incline up to 28° or down-grade, (3) the belt may be fabric, rubber, metal, woven wire, etc., (4) the belt supported on flat surface is used as a carrier of objects, or as a basis for a production line, (5) the belt supported by flat rollers will carry bags, bales, boxes, etc., (6) the belt supported by concave or troughing idlers is used to handle bulk materials, (7) metal mesh belts are used for applications subjected to heat, cold, or chemicals, (8) speeds range from 3 to 200 ft per min.

Brines

Calcium chloride is used for temperatures down to –34°C (–30°F). If made from pure materials it will not unduly corrode iron or steel. Generally the acidity is adjusted by the addition of lime to a *p*H of 8.5. Sodium dichromate (0.2%) is added to the brine. It attacks zinc or galvanizing, generating hydrogen, which in a confined space may produce an explosive mixture.

Sodium chloride is used for temperatures down to –18°C (0°F). While it may be cheaper, it causes considerable corrosion to iron and steel unless very pure.

The freezing-point of these brines is determined by the specific gravity of the solution. Where commercial materials are used a certain amount of impurity is always present, and a higher specific gravity is required for a given freezing-point than that given in the tables for pure materials.

Both salts are highly hygroscopic and tend to weaken in time by the absorption and condensation of water vapour. Where brine spray coolers are used, periodic concentration or strengthening must be carried out.

Weak brines form a coating of ice on the cooling surfaces, thereby insulating them and causing an immediate falling off in the efficiency of the machine.

Other solutions suitable for low-temperature applications are alcohol, acetone, ethylene glycol, methylene chloride, and paraffin.

Bucket Elevators

See ELEVATORS.

Bulk Conveying

Flight conveyors provide for the continuous movement of many classes of materials in bulk. Application is where lumps of small materials of a non-abrasive nature, such as root vegetables, may be moved along a trough by means of flights attached at regular intervals to an endless chain. Materials are moved horizontally, or down inclines, or up inclines not exceeding 45°. Where materials of small-lump particle size, or smaller, are to be handled continuously in bulk, resort may be had to enclosed conveyors of the *'en masse'* type. Movement is effected economically and dustlessly within the enclosure, by the principle of coherence

of the mass; horizontally or vertically. Other equipment for mass or bulk movement of materials include vibrating, troughed belt, steel band, apron and screw conveyors.

Advantages offered by vibrating conveyors are dustless operation and no contact between moving parts and the load of material. In addition process operations may be performed whilst the materials are being conveyed. Troughed belt conveyors comprising an endless belt supported by concave or troughing idlers are generally used to handle bulk materials, but alternative designs claimed to offer operational advantages are available. These include conveyors formed by running a flat belt on a dished sheet metal bed and those in which is incorporated a specially moulded belt.

The latter is a one-piece moulded construction of trough-shaped cross section. Running on parallel rollers, the conveyor is said to operate with reduced spillage, less degradation of materials conveyed, less dust and reduced maintenance costs. Bulk materials conveyed include vegetables, grain, granular food products and offal from freezing temperature to 150°C (302°F). Based on a density of materials of 56 lb/cu ft/ton, a 12-in x 3-in belt has a carrying capacity of from 31 to 187 tons/hr (21 to 126 cu ft/min) at belt speeds of 100 to 600 ft/min respectively.

Under some processing conditions it is advantageous to convey bulk materials on flat belt conveyors running on parallel rollers or beds, particularly if material has to be unloaded at any point along the running belt. The apron conveyor, a modification of the slat conveyor, and the steel band conveyor are of value here. The former, however, when used for bulk handling, usually has side aprons for holding larger quantities of materials. In this form they are sometimes called 'pan' conveyors and are limited in operation to single-point discharge. Steelband conveyors offer advantages in that they meet the stringent hygienic requirements of food processing, operate satisfactorily when handling sticky or greasy substances and are also suitable for applications involving processing of bulk materials during movement by the conveyor. In this case increased load-carrying capacity can be obtained by using side skirt boards.

The screw conveyor also forms an essential component in many bulk handling systems, comprising, in conventional form,

a trough of 'U' shape, either covered or uncovered, fitted with a screw for promoting movement of the material through the trough. Many design variants occur. One of these is the flared trough conveyor; specially designed for handling in meat and bone plants and capable of dealing with materials ranging from quartered carcases, which ride above the screw, to meals which are conveyed lower in the trough. The flared profile prevents pieces of bone and meat wedging and allows a large volume of material to be piled on top of the screw. There are no intermediate bearings to obstruct conveying, the screw running on brass strips in the trough.

Major advantages in bulk handling have occurred in flour mills, bakeries and biscuit factories, particularly the latter, which are generally equipped to receive in bulk ingredients such as flour, sugar, fats, milk, glucose, syrup and malt. Here bulk handling of flour and sugar is synonymous with pneumatic conveying. A typical system of this type would incorporate, for example, a single or two-stage Roots type rotary-piston blower, a design delivering clean air at pressures up to 25 psig and having positive-displacement characteristic which assists system stability. Sonic valves may be introduced into individual air lines of a multiple system to eliminate interaction and to permit operation from a single central compressor. Each valve is a form of automatic control which has no moving parts but maintains a preset constant air flow regardless of wide load fluctuations. Before the development of the sonic valve, parallel operation of pneumatic conveyors from one compressor was impracticable, since load variations caused unbalanced air distribution and persistent choking.

Materials from storage bins are discharged into the conveying system through rotary feeders. For coarse, free-flowing materials, a gravity type is occasionally employed, but for fine, sometimes sticky materials such as flour and sugar, a pneumatic-discharge airlock is much more satisfactory. Rotary seals also form part of transit separator and ring-main extractor assemblies, the separator and extractor being mounted over the valve. Transit separators are employed in a pneumatic conveying system to separate the conveyed material from the conveying air. After separation the material is discharged from the base of the separator through the rotary seal, and the air is exhausted through a filter venting unit or into a central exhaust system by means of a hood arrangement.

A ring-main extractor is used to withdraw materials from a closed-loop pneumatic conveying line as required for delivery through a rotary seal to a service point, e.g., a packer or weigher. Where the flow requirement at this service point is less than the ring-main flow rate, excess stock is automatically recirculated in the ring-main without extraction.

Primary and secondary separators are used in a system. The former removes the bulk of the conveyed material from the air at the system discharge port. Where appropriate, a storage bin receiving the material may function as an expansion-type separator. In other applications a vortex-type separator is used. The secondary separator removes all traces of dust before the conveying air is discharged directly or indirectly to atmosphere. Textile-sleeve dust filters are applied to this duty. An airlock is also necessary at the conveyor discharge pint to ensure that no dust-laden air escapes with the material. When the primary separator is a storage bin, the bin discharger may itself function as an airlock, but in other cases it is usual to provide a rotary-type unit.

A further feature to be considered is that the association of pneumatic plants with automatic distribution systems has created a need for route-selector valves which can be indexed remotely to channel the conveyed material to the appropriate destination. These requirements are met by multiple selector valves and two-way diverted valves, both of which can be operated without leakage even when the flow of conveying air under pressure is maintained without index. The former are motorized and made in models capable of directing the flow of materials to one or two, four of eight point. The valves contain a rotor embodying a curved duct which can be aligned with every desired outlet port. The rotor is driven by a frictional h.p., geared motor through an electrical indexing mechanism, and it is controlled from a rotary switch mounted locally or remotely. The two-way diverted valve is designed for fitting into a conveying line at a junction to divert the conveyed material from one line to another without stopping the flow. The valve is operated pneumatically and may be controlled from any convenient location.

Carbon Dioxide

See REFRIGERANTS.

Carrene

See Refrigerants.

Carrousel Conveyors

See Chain Conveyors.

Chain Conveyors

Available in many forms, these conveyors are designed for the horizontal movement of materials over fixed paths or routes. The simplest type consists of one or more strands of chain with links adapted to drag the specific material along a trough. One or two chains with flat links are also often used for movement of materials where a circuitous path and sharp comers must be followed—as in bottling operations. Side rails guide the materials handled. Yet another form makes use of roller chains.

Lumpy or small materials of a non-abrasive nature may be moved along a trough by means of flights fastened at regular intervals along an endless chain. Known as a flight conveyor, is is made in three main types. These are scraper flight, suspended flight and roller flight conveyors. The scraper flight conveyor has a single strand of chain, or alternatively, rope or cable, which pulls the flights along the troughed cotton. It is often encicsed when used for bulk materials only.

The suspended flight conveyor is also a single-strand equipment, but with wearing shoes attached to the flights, which suspends them on the edge of the trough to clear them on the bottom. In the case of roller flight conveyors, the flights are kept clear of the bottom of the trough by rollers running on the edge of the trough. For heavy service, a double chain is used; with the chain and flights supported on rollers.

Slat and apron conveyors are probably the most widely used of the chain conveyors. The former has a carrying surface made of wood or metal slats, attached at their ends to two roller chains usually running in steel guides. The load can be placed directly on the slats, or in containers which are placed on the slats, whist the conveyor itself may be placed at work height or floor level. The apron conveyor is a modification of the slat conveyor, in that the slats overlap each other to form a continuous 'leak-proof' moving bed.

The maximum angle of inclination is approximately 10° with a slat conveyor, but this may be increased to 45° by the use of cleats or flights, depending upon the type of materials handled. Apron conveyors, fitted with deep pans and/or cleats, can also be used as inclines up to 45°. However, for elevating or lowering at angles from 30 to 60° or greater pusher-bar conveyors are generally the best type to use. Also they are simple to operate, have a low initial cost and are easily adapted to automatic loading. They are particularly useful applied to roller conveyor systems as means of elevating packages form one section of the roller conveyor to the next, *i.e.*, when the conveyor is such a length that continuity of gravity movement is lost.

Another widely used chain conveyor is the tow-line. It consists of a series of floor trucks connected to an overhead chain, driven by a synchronous motor and pulling the trucks over a definite circuitous route, or driven by a chain operating in a channel below floor level. A conveyor of this type finds use in large warehouses or storerooms as a medium for distributing incoming goods or gathering items for outgoing order. Alternatively, it may be used as a continuous moving storage for supplying manufacturing areas.

Chain Hoists

See HOISTS: CHAIN, PNEUMATIC AND ELECTRIC.

Characteristics of Refrigeration Systems

The different types of refrigeration systems have quite different characteristics of capacity and power with varying evaporator temperature and with varying condenser temperature. The capacity of the reciprocating and rotary compressor varies slowly with a change in evaporator temperature, and the variance of power requirements is relatively small for a change of evaporator temperature. On the other hand, the capacity and power of the centrifugal machine vary rapidly, and the capacity of the steam ejector also varies considerably. Thus both these latter types tend to be more nearly self-regulating than the reciprocating and rotary compression type.

On the other hand, the operating range of the latter near standard capacity is superior. Although the capacity of the reciprocating and rotary compressor is little affected by the

condenser temperature, the power of the compressor is greatly affected, while the reverse is true for the centrifugal compressor. The condenser temperature has no effect on the capacity of the steam ejector type of compressor until a certain point is reached, beyond which the capacity is zero.

Steam jet refrigeration requires from three to ten times as much condenser water as other types of mechanical refrigeration, but its capacity is not affected by condensing water temperature as long as the water does not greatly exceed 38°C (100°F). Consequently, steam jet systems are well suited to those applications where condensing water is cheap, or where condensing water is rather high in temperature. Steam jet refrigeration is better suited for use with evaporator temperatures above rather than below 4.4°C (40°F).

Chilled and Frozen Produce

Produce storage is embodied in two main classifications; live and dead. The former, which includes fruit, vegetables, eggs, etc., is usually subject to conservation by refrigeration methods with the objective of deaccelerating metabolic activity. (*See* FRUIT AND VEGETABLE STORAGE.) Recent developments have, however, resulted in processing for long-period storage by freezing. (*See* FLUIDIZED BED FREEZING.) With dead produce, embracing such materials as meat, poultry, fish, pre-packed cooked foods, dairy products, etc., the aim is to retard the action of micro-organisms and the chemical and physical processes affecting quality. Response is to temperature a few degrees above freezing down to as low as –30°C(–22°F), depending on the commodity and the period of safe keeping desired.

Whilst limited extension of safe keeping is secured for dead produce by chilling to temperatures around freezing, long period storage is not possible without resort to freezing and frozen storage techniques. Temperatures should be as low as possible, particularly for difficult foods such as fish or meat with a high fat content. The freezing methods now commonly used include: *(a)* air blast freezing; *(b)* indirect contact freezing (*see* CONTACT PLATE FREEZING); *(c)* immersion freezing; *(d)* fluidized air freezing. Modern chilling and freezing practices are exemplified by the processing of meat and poultry; as briefly follows:

Meat—Short period storage requires that the meat is rapid

chilled immediately following slaughter at initial air temperatures of –3°C (26.6°F) for beef and –5°C (23°F) for pork, followed by temperatures of –1°C (30.2°F) and –2 to –3° C (28.4 to 26.6°F) after the surface of the meat has attained a temperature near its freezing point. Forced air circulation is employed, at velocities in the order of 3.28 to 6.56 ft/sec for an air stream usually across and sometimes partially along the carcases. Continuity in refrigeration is necessary, at cold storage temperatures between –1 and +2°C (30.2 to 35.6°F) with a velocity sufficient for uniform air distribution whilst keeping the weight loss low.

Long period storage requires freezing to below –10°C (14°F) to arrest the growth of micro-organisms and slow down the rate of all the processes responsible for deterioration; a carcase or part of, or portioned as pre-packed cuts. It is, in the case of carcases, effected after slaughter (pre-rigor freezing), or after ageing, in cold air of –25 to –40°C (–13 to –40°F) at air velocities between 0.82 to 13.12 ft/sec and relative humidities as high as possible. Optimal storage temperatures are governed by intended length of storage. They can vary between –12 and –29°C (10.4 and –20.2°F), the lower value being needed for pork. High humidity is required to minimize weight loss and freeze burn (surface drying) and in all cases air circulation requires to be a minimum for uniform temperature distribution. Two-stage refrigeration equipment is normally employed.

Poultry—Poultry may be chilled and cold stored, or frozen and freeze stored. For long storage life resort is usually had to short period immersion or spraying at –16°C (3°F) to give approximately 25 per cent freeze, followed by treatment in a freezing chamber with slow air movement for up to 6 hr at –30°C (–22°F). Alternatively, resort may be had to blast freezing at temperatures of –25 to –40°C (–13 to –40°F) and air velocities of 8.2 to 13.12 ft/sec.

Storage may be effected in combined sub-zero freezing and storage rooms or in freezer stores held at –18°C (0°F) and lower, with the temperature as constant as possible. Shelf life is governed to a considerable extent by fat stability, which varies with the kind of bird. Thus, young chicken store longer than frozen duck, geese or turkey. Low temperature and good packaging are imperative, mitigating freezer burn likely to occur at higher temperatures.

Coefficient of Performance

The coefficient of performance of a refrigerating system is the ratio of the refrigerating effect (*i.e.*, the heat absorbed by the evaporator) to work of compression, both expressed in the same units. The highest theoretical value it can attain is given by the expression T_1/T_2-T_1 where T_1, is the lowest temperature of the refrigerant (the evaporation temperature) and T_2 is the higher working temperature (condensation temperature), both on the absolute scale. From this it will be seen that the higher the evaporator temperature and the lower the condensation temperature, the greater will be the ratio of refrigeration obtained for power expended, or the smaller the compression range, the less power will be required to produce a given refrigerating effect.

Compressors

See MECHANICAL REFRIGERATION.

Condensers

See MECHANICAL REFRIGERATION.

Constant Weight Feeders

The function of a constant weight feeder is to feed and weigh, continuously and accurately, any dry free-flowing or ground material, at a constant predetermined rate of flow in terms of mass units. They may thus be used for blending solid materials , or, in conjunction with metering pumps, for blending solid with liquid materials. Electric, mechanical, pneumatic and electronic systems are employed; singly or in combination.

The primary and basic part of an electrically-operated equipment is, for example, an electric vibrating power unit connected to a feeder deck. Attachment is usually at an angle of 20°, so that as the deck moves forward it also moves upwards at this angle, and as it moves backwards it descends at the same angle. Material on the deck is thus moved forward and upward. However, the material being free to move does not return with backward movement of the deck, but falls under the slower force of gravity until it is intercepted by the next forward and upward stroke.

The length of stroke, and hence the rate of materials movement or feed, is adjustable in a given feeder from the maximum

downwards. The stroke frequency is at all times constant since it is determined by the electrical supply frequency, so the amplitude or stroke is varied by means of a variable resistance to give the desired speed of travel of any material on the deck. In the case of a constant weight feeder, the rate of feed is again governed by the length of stroke, *i.e.*, the amplitude of vibration, but instead of being manually controlled through a rheostat, it is effected automatically by means of an electronic circuit initiated by a weigh-belt mechanism. Fluctuations of weigh-belt balance cause instantaneous adjustment of the vibrating feeder to maintain accurate output; to a maximum of ±1 per cent from the desired quantity based upon ten minutes' operation.

The weigh-belt is usually a continuous rubber-covered belt conveyor with short centres. The unit is so mounted that it pivots on knife edges at the centre-line of the head or discharge pulley, with the tail-end of the conveyor resting on a lever connected to a scale beam having adjustable poise weights. This method of mounting gives the greatest leverage, and the greatest sensitivity to the tail-end of the conveyor, and it is to this end that the vibrating feeder discharges the material being fed. Electrical units transmit signals to a control panel indicating the balance conditions of the weighing system, and any out-of-balance either way is immediately rectified by automatic adjustment of the feeder. The signalling is effected by means of an electronic device which operates without mechanical contact, thus eliminating any drag or friction on the scale mechanism, which might effect its accuracy. The scale beam is normally calibrated to read directly in lb of material per ft of belt, and the capacity of the machine is varied by manual adjustment of the poise weights.

Contact Plate Freezing

With this method freezing is effected by conduction, the product being brought into intimate contact with metal plates through which sub-cooled bring or evaporating refrigerant is circulated. Freezing is very fast, almost as fast as by the brine immersion methods, and the plates can be incorporated in plant giving continuous and automatic production.

Contact plate freezers are made with plates vertically or horizontally disposed. Vertical plate freezers are particularly suitable for freezing whole fish, fish fillets, boned beef, offal, and

similar materials up to a block thickness of about 5 in. They are also used for fish, meat, fruits and vegetables packed in rigid containers. Space occupancy for a given output is normally less than for any other type of freezer; arrangements are incorporated for mechanical feed to the machine and block harvesting. Intimate contact between the plates and product is effected automatically, usually by uniform application of hydraulic pressure to the plates. The vertical position of the produce or packages during freezing, with headspace at the top, minimizes insulation effects due to air. For the production of consumer and catering packs, especially those presenting two flat surfaces to the freezing plates, a horizontal plate freezer is usually used. Loading and unloading can be manual, semi-automatic or fully automatic; continuous conveyor type machines are made for large outputs.

Conveyors

Practically every materials-handling problem of the horizontal or inclined fixed-path type can be solved by one or other of the floor-level, work-level, or overhead conveyor system, while usage is extended by portable conveyors constructed to be wheeled to the point where movement of materials is required. They are adapted to the handling both of bulk materials and of materials in unit packages, the latter being in the form of single pieces or a number of pieces assembled as a unit package. Designs include gravity roller, wheel, spiral, live roller, belt, chain, worm, and automatic types.

Cranes

Applied to the lifting and transporting of loads, both light and heavy, cranes offer a flexible means of handling materials within their range, which varies according to the type and size of crane. Thus, an overhead travelling bridge crane can serve the width and length of the area encompassed by its runways, whereas a tractor crane is relatively unlimited in its area of service. Factory cranes operate without interference with work on the floor and neither require floor space nor are affected by cross traffic or non-uniformity of loads or rates. Of the many types those particularly used are the hand or powered portable cranes, jib and pillar cranes, derricks, and gantry, travelling bridge and monorail cranes.

Cryogenic Nitrogen Freezing

Freezing with cryogenic nitrogen is a comparatively recent commercial application when compared with other methods of quick freezing. Here the actual refrigerant is used to effect freezing, and not a refrigerating medium that must be sub-cooled by refrigeration plant, as in the case of brines and air. Freezing is carried out directly as the product is in direct contact with the nitrogen. Ultra-fast freezing results, which, it is claimed, locks in food flavours and permits retention of elements lost during slower methods of processing.

Systems vary. In one, foodstuffs placed in wire baskets are transported through a tunnel by cradle type conveyors, wherein they are first passed through a nitrogen mist formed by spraying the foodstuff with liquid nitrogen and secondly, immersed in nitrogen [temperature of –195.5°C (–320°F)], before being discharged solidly frozen. Such a method lends itself to a wide range of products, including packaged pre-cooked foods, and especially to materials of a fragile nature.

In another system, liquid nitrogen is expanded at high velocity into a multi-zoned conveyorized freezing tunnel. Nitrogen vapour is circulated within the tunnel and this, by latent heat transfer on evaporation, maintains environmental temperatures in the order of –156.7°C (–250°F). Freezing rates are further accelerated by the high velocity of the expanding nitrogen, up to 7,000 ft/min. At this speed the flow of circulating nitrogen is highly turbulent, reducing the thickness of the layer of insulating air surrounding the produce, which facilitates heat transfer between this and the freezing atmosphere.

Defrosting

Any pipe cooling system which is held at temperatures lower than freezing soon becomes coated with frost crystals which in time consolidate into a thick layer of ice. This insulates the refrigerating medium from its source of heat, so that a lower temperature must be carried to maintain the same heat gradient. Longer plant running hours and less efficient running conditions ensue. The outside temperature of a heavily frosted pipe tends to rise until it becomes that of melting ice and the control of chamber temperature becomes sluggish. The humidity of the store rises and damp conditions may accelerate the growth of destructive moulds

or slimes.

Defrosting should be a regular routine by scraping or chipping by hand; use of chemical solvent; circulating warm brine or refrigerant through the cooling coils; and electrical heating, arranged to be automatic in an off-period. In some circumstances automatic defrosting by water is possible.

Dielene

See REFRIGERANTS.

Direct Expansion

A cooling system by direct expansion is one in which the pipes carrying the evaporating refrigerant are mounted directly in the cold chamber or in contact with the goods being cooled.

The cost of a brine circulating system is saved and the power cost is somewhat less, since the compressor operates with a higher suction pressure. Against this a number of regulating valves are needed to control the various circuits in a large system, which, unless automatically controlled, can be a source of loss.

Direct or Indirect Brine Systems

In the direct system of refrigeration, the coils of the evaporator are placed in the storage rooms of the refrigerator, and liquid refrigerant is allowed to expand into them. In the indirect (or brine) system, the storage rooms are cooled by means of pipes filled with cold brine which has been previously cooled. Both systems have advantages and disadvantages. The indirect (or brine) system is more frequently used than the direct. A brine tank or a brine cooler is required in the indirect system, and a pump must be used to keep the brine in circulation. The tank and the pump add to the first cost of the indirect system, making it greater than the cost of the direct system.

In small plants, the operating cost of the indirect system is less than that of the direct system; while, in very large plants, the direct system has the advantage. In order to maintain a fairly even temperature in the cold-storage rooms, the direct system must be operated day and night, as shutting down the plant means stopping the refrigeration process. On the other hand, if the quantity of the brine in the system is large, it may be kept in circulation by

operating the brine pump during the night, while the rest of the plant is closed down.

In the indirect system, there are two transfers of heat. In the direct system, heat is removed directly from the substances to be refrigerated, and there is only one heat transfer. In order to produce the same cooling effect with both systems, the liquid refrigerant must be evaporated at a lower temperature in the indirect system than in the direct system. This adds more work on the compressor for an increase in range of temperature and, in consequence, also, in the range of pressure requires greater pressure limits for the operation of the compressor.

In general, a more even temperature of the storage spaces may be obtained by the indirect than by the direct system. All systems are subjected to variations in temperature by (1) irregular flow of liquid refrigerant through the expansion valve and (2) variations of speed of the compressor. The temperature variations are readily taken up by the brine in the indirect system, as the brine has a high specific heat, and a large quantity of brine is affected. The direct system has the disadvantage that should a leak occur, the vapour of nearly all refrigerants would injure many kinds of foodstuffs.

Elevators

There is but a short step in design form between conveyors and continuous elevators; for effecting vertical movement of bulk materials and piece goods. In many instances the designs can be combined to form a conveyor-elevator, whereby both horizontal and vertical movement is achieved. The proper definition of a continuous elevator is a machine for raising in a constant steam loose materials, packaged materials, or packages of various shapes and sizes. In every case the carrier is shaped to suit the material or the object lifted. Thus it is possible to divide elevators into two major classes, (1) package elevators, for isolated objects and goods in containers, and (2) bucket elevators, for loose materials. It will, of course, be understood that certain loose materials may be lifted continuously without using bucket elevators at all, also intermittently, by means of grab-cranes, hoists, etc.

For the sake of convenience and clearness it is usual to divide the two classes of elevators into types, thus package elevators fall into three main types, which are (1) arm elevators, for short lifts,

(2) swing-tray elevators, for either long or short lifts, and (3) finger-tray elevators, mainly for relatively long and heavy lifts. Bucket elevators may be divided into four main types. These are (1) vertical belt and single-strand elevators, for both light and heavy materials, (2) inclined elevators with spaced out or discontinuous buckets, including curved elevators; (3) inclined continuous overlapping bucket elevators, usually single-strand and mostly used for lumpy materials, (4) vertical dumped elevators, including, also cranked elevators, which are always double-strand. To the foregoing may be added further types.

Rigid-arm Elevators

This is the simplest type of equipment for elevating materials vertically or at high angles. It is a cheap, compact and efficient type of labour-saving machine, which is so simple in its mechanical details as to be practically foolproof. The running gear being perfectly balanced and the speed slow, the power absorbed in lifting a series of loads is often so small as to be almost negligible. The loads handled are barrels, boxes, bags, etc. The basic construction consists of two endless chains running over top and bottom sprocketed wheels, whilst fastened at specific intervals are the rigid arms for carrying the materials to be elevated.

There is only one receiving and discharge point, therefore the elevator can only be used between two working floors. The action of the operation is that the rigid arm picks up the load at the loading station and automatically discharges it over the top terminal wheels. Occasionally an automatic discharge of goods on the ascending side of the elevator is required. This may be solved by making the top terminal of relatively large diameter, and unloading chain-deflecting wheels; with the object of canting the carrier arms sufficiently to enable the load to slide off the arms on reaching the required discharge point.

Swing-tray Elevators

The arm elevator has its limitations, as it is unsuitable for serving several floors and for lifting breakable goods. It is essentially a single-purpose machine rather than a machine of general utility, like a cage hoist, which will take anything that comes along. It is a case of one machine for one job. Of more general utility is the swing-tray type of light-package elevator, which is well adapted

for lifting and lowering goods in bottles, cans, baskets, crates or other containers through any required number of floors.

The machine consists of two endless chains running over chain wheels at the top and bottom. At intervals, swinging trays are suspended between these chains, the trays being in effect pivoted carriers and by this characteristic always maintain their position, the centre of gravity of the trays being well below the point of suspension. The load-carrying capacity of these carriers is very high, and the power necessary to drive them low, resulting in an efficient handling device. It is usual to fit the driving element on the top of the elevator, whilst the tensioning mechanism is fitted to the bottom.

It should be observed that no harm is done if loads are left on the swing trays, as they merely go round and round the circuit. A certain amount of fencing is desirable from the safety point of view round each floor opening through which an elevator passes. In some cases the entire elevator is enclosed within a sheet steel housing, fitted with doors at the point of loading and discharge. The maximum capacity of a swing-tray elevator is governed by the rate at which it is possible to feed the loads on to the trays by hand. When the trays are 4 ft apart and the chain speed is 1 ft per sec, there is a time interval for loading of 4 sec and a capacity of 15 loads per min or 900 per hr. This is about the limit of feasibility in respect of capacity, when resort is had to hand loading.

Finger-tray Elevators

The swing-tray elevator has obvious disadvantages applied to certain handling conditions. Packages exceeding 100 lb in weight are not easily fed on to the moving swing-trays and removed from they by hand. for heavy packages it becomes necessary to arrange automatic pick-up and discharge gear, and sometimes this is done even for light packages. In both cases, automatic finger-tray elevators cater for the handling conditions.

For light duties the equipment incorporates a single chain only and over-handling finger-trays which intermesh with hinged loading grids at each working floor on a multi-storied factory. Thus packages are picked up when desired on the ascending side, pass round the upper, or top terminal, and are lowered on the descending side for discharge as required on to an inclined grid.

But for heavy-duty finger-tray elevators double-strand chains are always adopted.

Elevator-conveyors

The operation of the swinging-tray elevator-conveyor is similar to that of the swinging-tray elevator, the only difference being that a dual movement is obtained—that is, movement of elevating and conveying instead of elevating only. The stabilized tray elevator-conveyor differs from the swinging-tray elevator-conveyor in one very important feature; that is by reason of their particular design the trays never leave the horizontal position. In the swinging-tray the horizontal position is maintained by reason of the centre of gravity being well below the point of suspension, the tray hangers being suspended at the top to the continuous chains by pivot pins.

While this caters for many materials handling problems, there often arise instances where even the swing experienced with these trays is sufficient to prove a serious production problem and a more stable tray is necessary. Such problems are eliminated by the use of the stabilized-tray elevator-conveyor, and it is mainly used for drying, processing, or cooling. Instead of two chains, four are used, two of which are hauling chains and two are stabilizing chains. The trays are pivoted at the centre, the pivot or shaft is connected from the hauling chain by a stabilizing crank to the stabilizing chain; the action of this is to hold the tray rigidly in position at all points of its travel.

Bucket Elevators

Bulk materials may be elevated by means of a series of small buckets or containers kept in constant motion by belts, chains or cables, to which they are mounted. Other types of equipment designed to elevate bulk materials depend upon the action of an enclosed tube through which a skeletonized chain is drawn, whilst in some instances a rope or cable fitted with various types of buttons or flights may be employed. These achieve vertical movement through induced flow of the materials.

The simplest of the bucket elevators is known as a vertical belt elevator, in which the buckets are bolted to a rather heavy rubber and canvas belt. In a machine of this type the line joining the shaft-centre to the edge of the discharge chute may be inclined at 20 to 30° to the horizontal, whilst in the case of a very slow-moving

machine the angle may be as much as 60° to get the chute low enough to receive the bucket discharge.

The top wheel of the vertical chain bucket elevator is usually smaller in diameter than the head wheel of a belt elevator and this may either have teeth or be toothless. A plain wheel or roller is apt to be quieter than a sprocket-wheel, and the frictional grip is sufficient to prevent slipping in normal working. The bottom chain wheel may also be toothless; but then there is the danger that the bottom shaft will cease to rotate in its bearings whenever the chain is allowed to get too slack.

A clean gravity-discharge can be obtained from an elevator with spaced buckets inclined at 60 to 70° to the horizontal at a relatively low speed by arranging the discharge chute vertically under and well below the discharge point. Some advantages of the inclined conveyor as compared with the vertical are: (1) the pick-up in the boot is improved, the buckets filling better; (2) there is more latitude of choice in the position of the boot; (3) the discharge is better and the chute can often be much shorter.

The range of speed is from 1½ to 3 ft per sec, a very common speed being 2 ft per sec, or 120 ft per min, for a fair-sized elevator having buckets round about 18 in long on a chain of 6 in pitch. Small elevators have chains of shorter pitch, and can well run faster. Durability dictates relatively low speeds and large buckets, whilst low first cost demands higher speeds and smaller buckets. Buckets of standard type should be spaced well apart to avoid 'interference' and a scattering discharge into the chute. The bucket interval commonly ranges from 15 to 30 in, according to the size of bucket and pitch of chain.

Inclined continuous-bucket elevators are specially suitable for handling lumpy materials, but are also much used for materials in smaller pieces. The principle of a continuous overlapping bucket elevator is that the steel plate buckets are so shaped as to form chutes at the discharge point; the contents of each bucket falling on the back of the bucket in advance and sliding quietly off without much fall into the discharge chute. Thus the discharge is very easy at a very slow speed of about 60 ft per min, and there is a minimum of breakage. At the feed point the material is fed directly into the rising buckets from a chute and there is no dredging. Some very large and very long elevators of this type have been constructed.

Bad delivery at slow speeds of an ordinary vertical bucket elevator may be overcome by having resort to a dumped elevator. The design provides for the deflection of the chains on the return strand so as to enable the discharge chute to be fixed vertically below the buckets at the point of discharge.

Elevator Hoists

See HOISTS: CHAIN, PNEUMATIC AND ELECTRIC.

Equipment Control

There are few operations performed by fixed handling equipment that cannot be monitored from a centralized position, particularly if the actuating devices are operated in conjunction with pneumatic or electro-pneumatic mechanisms. For example, different conveyors operating to different speeds may be slowed down or speeded up as required and in proportion to each other, by master controls. Materials may be diverted from off a conveyor and from conveyor to conveyor by pneumatic means, controlled remotely, whilst trip mechanism, mechanically or pneumatically operated, may be incorporated in a control system to achieve a number of desired actions.

The development of various types of electronic controls has increased the automatic selectivity ability of the conveyor. For example, on converging lines one will be kept closed while packages move past the critical point on the other line. This may also be accomplished by means of various mechanical devices.

This idea of selectivity has been carried still further in conveyor handling systems devised to segregate boxes and cartons of various types. With these one operator standing at a central control panel can divert boxes or other containers into any number of side channels. As the box passes the control panel, the operator selects the station or point at which it is to be diverted, by pressing a button which sets up an electric path in a relay circuit to record its passage along the main conveyor line. As the box continues, it passes over a series of switches located on this line. Each switch, by means of a relay circuit, automatically records the position of the box. When the box reaches the point where it leaves the main line, the relay circuit has recorded this fact and the box is automatically diverted.

Photoelectric controls may also be used to sort packages

moving along a conveyor. This may be done by a number of different methods. On a conveyor line carrying packages, the beam is set above the short packages and below the top of tall ones. As the latter pass along the beam, the beam is interrupted, which operates a switch diverting them to another line. A similar method is used to sort packages by width. In this case the light source and the photoelectric tube are mounted so the light beam can pass vertically between the rollers of the conveyor. Cartons to be diverted are placed on the conveyor so that the wide side will break the circuit and actuate the switch.

Sorting may also be done by a scanner which mounts the light source and photoelectric tube side by side. The light-sensitive element is actuated only when light of a given intensity from the light source is reflected from a foreign surface. It sorts unlabelled cans by reflecting the light from the side of the cans as they pass on the conveyor. The labelled cans do not reflect enough light to actuate the diverting unit and thus continue on their way. The scanner can also be used to sort packages by their markings. The light may be used to hold a line switch open or shut. Unmarked packages reflect enough light of hold the relay open and the switch closed. The reflection from a marked carton is less intense and thus permits the switch to open and divert these cartons to another line. An extra light source is used to keep the switch closed when no cartons are passing the scanner.

Evaporators

See Mechanical Refrigeration.

Expansion Valves

See Mechanical Refrigeration.

Finger-Tray Elevators

See Elevators.

Flake Ice

Installed in a factory flakes of ice and chilled water are immediately available for manufacturing operations where heating up due to chemical reaction or mechanical means is to be avoided or reduced. In some food mixing operations the requisite amount of water can with advantage be replaced by flakes of ice.

Flight Conveyors

See CHAIN CONVEYORS, BULK CONVEYING.

Fluidized Handling

When air is passed through a bed of powdered or granular solid materials the bed will lie dormant until the velocity is such that the pressure drop over the bed is equal to the bed weight. The velocity at this point is known as the minimum fluidization velocity. Further increase in air velocity causes the bed of material to expand, without any increase in pressure drop. Continued rise in velocity imparts a turbulent motion to the bed, which then assumes many of the properties of a boiling fluid. These principles are embodied in the design of fluid-bed dryers, fluidized bin dischargers and air float conveyors. Operation is similar in that pneumatics are used for materials movement.

Fluidized bin dischargers offer an alternative to mechanical dischargers for withdrawing supplies of powdered granular material from storage bins, possessing the advantages of simple design, easy accessibility, no moving parts subject to wear and space saving by allowing the storage bins to be flat bottomed. The discharger incorporates a porous deck on which the material rests. When discharge is required, compressed air is introduced through the deck. This air expands the lower layer of material, eliminating internal friction and causing it to flow like a fluid to the outlet. An uncontrolled flow of material is provided, and so it is usual to fit a blowing seal or rotary seal at the outlet to regulate the discharge rate. Should a variable discharge rate be required, the seal speed can be varied or, alternatively, a blowing seal with by-pass regulator can be used.

Almost identical features are incorporated in the design of air-float conveyors. The general principle of operation is based on the fluidization by air of the material to be conveyed which will then run down a small incline in a manner similar to that of a liquid. As the amount of air used is very small, there is no dust problem, and there is no limit to the number or position of the feed inlets and discharge points. Control is simple and can be effected remotely. Construction comprises a rectangular duct separated transversely by a porous plate, the upper section housing the material to be conveyed and the lower section forming a pressure box for the fluidizing medium. Low pressure air diffuses through the porous

plate, fluidizing the bed of material. Friction between the particles, and the particles and the plate, is thus nullified and the fluidized mass flows down the plate, inclined at 6 to 8 degrees to the horizontal. A single blower can operate a complete installation, and the conveyors ensure maximum clean-out when used in silo extraction systems and similar applications.

Fluidized Bed Freezing

Low temperature is used in fluidized bed freezing, but in this case the air, instead of flowing counter or cross-current to the direction of product, as in blast freezing, is caused to flow upwards through a bed of material. It thus supports, conveys and freezes the product without any need for mechanical moving parts. Fluidized bed freezing is applicable to food particles of a size sufficiently small to be impervious when closely packed, and sufficiently large to float on an air cushion, as distinct from very small particles which tend to become entrained in air currents.

Super-cooled air is passed through the bed of material in sufficient volume to effect the required heat transfer, and at a velocity above that at which the pressure drop across the bed equals the bed weights. At such a stage the bed of solids moves upwards, the degree of movement being dependent upon such factors as the air velocity, weight of the individual particles and the density of the bed. The action is similar to that occurring in a fluidized bed dryer, whilst horizontal movement is secured by having the permeable base plate slightly inclined towards the delivery end, as in conveyors of this design.

There are various modes of fluidization, but in the case of small particles the cold air will usually pass through the bed in discrete bubbles, giving it the appearance of a boiling liquid. Constant movement and mixing of the bed takes place, with the heaviest bodies or particles sinking to zones of lowest fluidizing air temperatures. The bed temperature will be very close to that of the outgoing fluidizing air, which will have suffered a very sharp rise in temperature immediately on entering the bed. This means that quite low temperatures can be used to freeze heat-sensitive materials, with a consequent gain in efficiency. Suspended separately, not only do the bodies freeze quickly and uniformity throughout the bed, but they freeze without clustering. This results in a free-flowing product which can be poured from a pack

in any desired quantity and the remainder returned to a domestic refrigerator for future use.

Processing is suitable for comparatively light-weight bodies such as peas, broad beans, sprouts, diced vegetables, mushrooms, prawns, potato chips and all berried fruits including strawberries, blackberries, bilberries, black and red currants. Heavier bodies such as carrots, fish fingers and cakes, and sausages can be satisfactorily frozen, whilst the application has also been extended to fresh cream sponge, pies and meals-on-trays.

Fork Trucks

See INDUSTRIAL TRUCKS.

Freeze Drying

See DEHYDRATION CHAPTER.

Freon

See REFRIGERANTS.

Fruit and Vegetable Storage

The problems associated with the cold storage of harvested fruit and vegetables are those of slowing senescence without damage to the produce. They are living things and thus during the ageing, or senescent, processes absorb oxygen, give off carbon dioxide and evolve heat. In fact, the rate of respiration indicates the keeping qualities of the produce, tissues which respire rapidly being short-lived and *vice versa*. The heat production of some everyday fruit and vegetables, calculated from the rate of carbon dioxide production, are shown in Table 1.

Cold Storage

In general, immediate chilling of fruit after harvesting is needed, followed by storage in insulated rooms at a temperature of 1.1 to 3.3°C (34 to 38°F) maintained by the usual mechanical means of refrigeration, the atmosphere of the store remaining for all practical purposes of the same constitution as that outside, *i.e.*, 79 per cent nitrogen and 21 per cent oxygen, there being only a trace of carbon dioxide. Successful storage under these conditions are, essentially, good air circulation and maintenance of a uniform temperature.

Table 1
Rate of Production of Carbon Dioxide and Heat by Various Fruits and Vegetables

Vegetables

Crop	*Temp.* °C	*Temp.* °F	CO_2 *cu ft/ton/day*	*Heat Btu/ton/hr*	*Specific heat*
Asparagus	1.1	34	12.9	300	—
Beet (red)	0	32	2.4-3.2	55-75	0.92
Brussels Sprout	0	32	6.9-10.8	160-250	0.91
Cabbage (spring)	0	32	4.3-6.0	100-140	0.95
Cabbage (winter)	1.1	34	3.6-5.4	85-125	0.95
Carrot (main crop)	1.1	34	1.5-3.0	35-70	0.4
Cauliflower	—.56	31	3.4-10.8	880-250	0.95
Celery	0	32	2.1-3.2	50-75	0.96
Leek	0	32	4.3-7.3	100-170	0.93
Lettuce	0	32	4.7-7.7	110-180	—
Parsnip	0	32	5.1-6.9	120-160	0.89
Pea (in pod)	.56	33	12.9-16.3	300-380	0.88
Potato	0	32	4.0	93	0.83
Runner bean	.56	33	8.1-15.0	190-350	0.95
Spinach (summer)	0	32	5.1-9.4	120-220	0.95
Spring onion	0	32	6.9-8.1	160-190	—
Turnip	0	32	1.7-2.6	40-60	0.95
Watercress	0	32	8.6-11.6	200-270	0.95

Fruit

Crop	*Temp.* °C	*Temp.* °F	CO_2 *cu ft/ton/day*	*Heat Btu/ton/hr*	*Specific heat*
Apple	0	32	1.5	35	0.92
Banana (ripening)	12.2	54	6.0-17.2	140-400	0.85
Blackberry	0	32	7.7-8.6	180-200	—
Blackcurrent	0	32	2.1-5.6	50-130	—
Grape	0	32	2.0	46.5	—
Orange	4.5	40	1.5	35	—
Peach	0	32	3.0	70	—
Pear	0	32	1.1-1.5	25-35	0.92
Plum	0	32	3-0	70	0.91
Rasberry	0	32	8.6-13.9	200-235	—
Strawberry	0	32	6.4	150	0.93
Tomato	12.2	54	6.4-9.5	150-220	0.93

(W.H. Smith, *Modern Refrigeration*, Dec. 1957).

Fruit and vegetables suitable for storage up to ten days at 0 to 1.1°C (32 to 34°F) and 4.4 to 7.2°C (40 to 45°F) (*see* notes):

List 1 0 to 1.1°C (32 to 34°F) American apples; grapes; pears (1); stone fruits (plums, peaches, apricots, cherries); cantaloupes or muskmelons (2).

All green vegetables (cabbage, broccoli, cauliflower); root vegetables (carrot, turnips, parsnip); asparagus; celery; corn; leeks; onions; peppers; salad vegetables (lettuce, endive, watercress (3).

List 2 4.4 to 7.2°C (40 to 45°F) English apples (4); cranberries; cumubers; grapefruit (5); honeydew melons (2); oranges (5); limes; ripe pineapples; new potatoes (6); watermelons (2).

Notes to Lists

(1) Pears should never be cold stored if the ground colour of the skin has begun to change from deep green to yellow. Storage of 'turning' pears will probably produce pear scald.

(2) At one time temperatures in the range 10 to 12.8°C (50 to 55°F) were recommended for storage of melons, in order to avoid injuries (water areas) which occur in long-term storage at lower temperatures. Modern work suggests, however, that the temperatures recommended here are not injurious over periods of 7 to 10 days.

(3) The condition of salad vegetables will be improved if they are sprinkled with finely crushed ice.

(4) If there is nothing else in the room appearing on List 2, English apples may be stored for longer periods by reducing the temperature of the room to 2.8 to 3.3°C (37 to 38°F).

(5) Grapefruit and oranges are frequently injured by very short exposures to 0°C (32°F). The injuries, which take the form of dark, halated spots on the skin, may not appear until the fruit is raised to normal temperatures.

(6) 7.2°C (45°F) is better than 4.4°C (40°F).

Controlled Atmosphere Storage

Formerly known as 'gas' storage, this refrigerated storage process was developed to extend the cold storage life of some fruits by controlling the supply of oxygen providing for the oxidation of carbohydrates producing carbon dioxide particularly

when applied to those variety of apples subject to low-temperature breakdown. The controlled atmospheres are obtained in either of two ways, a pre-requisite of each being a gas-tight storage chamber. In the simplest form, carbon dioxide resulting from respiration is allowed to accumulate until the concentration reaches about 10 per cent, after which controlled ventilation with air is used to prevent it rising higher. No attempt is made to regulate the oxygen concentration, which runs about 10 to 11 per cent.

Should, however, the carbon dioxide concentration remain too low, much of the potential extension of storage life may be lost with some varieties of fruit. On the other hand, too high a concentration will cause damage. The safe concentration level varies not only from one kind of produce to another, but also with variety. Thus, for Cox's Orange Pippins it is near 15 per cent, and for Newton Wonder apples it is as low as 3 per cent.

Furthermore, the safe level of carbon dioxide is often insufficient by itself to extend storage life, and the oxygen must also be controlled to a low level. Control of oxygen is effected by the respiratory action of the fruit whereby oxygen is gradually used up until the desired level is attained. At the same time the carbon dioxide is rising and control of this is effected by absorption by caustic soda in a suitably designed scrubber.

Another condition likely to be encountered is the storage of produce responding best to atmospheres relatively free from carbon dioxide, *i.e.,* a practical lower limit of about 1 per cent, and containing from 1 per cent to 2.5 per cent of oxygen. Here the low level of oxygen can be attained by injecting an inert gas, such as nitrogen, into the storage space.

Gravitational Movement

A good dictum to follow in materials-handling is that of never applying power for the desired movement if it can be effected gravitationally. For movement of materials between work areas for short or relatively short distances and for movement from a higher to a lower level, gravity roller conveyors, wheel conveyors, spiral conveyors and chutes afford, where practical, the simplest and most economical method.

Hand Trucks

The basis of all industrial truck design is the four-wheeled cart

or hand truck, intended to be pushed or pulled manually where relatively light loads are handled or where the distance transversed is relatively restricted. The exigencies of modern production have resulted in many variations of the original form, these being identified by arrangements of wheels, use of fixed or swivel wheels, method of steering and type of superstructure employed. The most outstanding development is the provision of either low- or high-lift trucks, achieved by mechanical action in some, and by hydraulic action in others.

Low-lift trucks are characterized by the ability whereby the load-bearing wheels are entered under the load to be carried, which is then lifted by a small amount to provide clearance whilst in transit. Models are available for use with either pallets or stillages. The high-lift hand truck possesses the same load-lifting and carrying characteristics as the low-lift type, but it has been developed to satisfy the demand for hand-operated units to provide a higher lift. The primary function of the machine is thus to elevate materials. Means for horizontal movement are incorporated to provide mobility.

Heat Units

The British Thermal Unit (Btu)—also used in the U.S.A.—represents the heat required to raise one pound of water through one degree Fahrenheit. It is the usual unit of commercial refrigeration and the heating and ventilating industry.

The calorie is the amount of heat required to raise one cubic centimetre of water through one degree Centigrade. It is used internationally as the unit of heat by all countries which adopt the metric system, and by scientific workers in Great Britain and U.S.A. For convenience, metric units of heat are expressed in kilocalories, 1000 calories, sometimes referred to as the 'great calorie'. When used for refrigeration this quantity is known as the frigorie.

1 Btu	=	0.2519 frigories of kcal
1 Btu/lb	=	0.555 frig/kg
1 Btu sq ft hr °F	=	0.2048 kcal M^2hr°C
1 Btu/cu ft	=	8.91 kcal M^3
1 kcal or frigorie	=	3.968 Btu

1 kcal/kg	= 1.8 Btu/lb
1 kcal M^2hr°C	= 4.882 Btu sq ft hr °F
1 kcal/M^3	= 0.112 Btu/cu ft

High-lift Trucks

See HAND TRUCKS AND POWERED TRUCKS.

High and Low Temperatures

A considerable amount of conveying equipment incorporated in a food processing line to give continuity in throughput must be capable of operating efficiently under conditions of high or low temperatures, or both, and these are sometimes coupled with complete immersion in liquids or operation in extremely heated atmospheres. Rubber belts are generally precluded from such applications, even though special types are made to withstand temperatures in the order of 112 to 150°C (233 to 302°F), and use made of wire belt or steel band conveyors or the many types of handling equipments employing conveying chains as a basis. Selection is governed largely by the application, although wide overlapping occurs.

For example, wire mesh belt conveyors are employed extensively in bake ovens and dryers, as are also carbon steel band conveyors, the perforated band type being especially suited to drying applications. Stainless steel band conveyors are used primarily in the processing and final stages of production, often in blast freezing tunnels at temperatures of –40°C (–40°F) and below. An interesting application here is in the continuous moulding and freezing of ice-cream at –45°C (–49°F). The blocks of ice-cream are carried on stainless steel bands straight from the moulding machines through the freezing chambers to the packing and despatch departments.

Conveyors based on chains, and arranged for materials movement at all vertical levels, are used for work involving high and low temperatures, humid atmospheres are complete immersion in liquids. These working conditions naturally introduce lubrication problems, as they do to a lesser extent when belt or band conveyors are used for the same purposes. They are, however, usually overcome by the use of a high-melting point grease of good mechanical stability for high temperature and, at the other end of

the scale, a lubricant permitting free running at minimum temperature, combined, if there is any danger of condensation, with a rust inhibitor. Lubrication problems likely to be encountered in very humid atmospheres or conditions of complete immersion are water wash-out and temperature effects. Hence the use of a lubricant having high adhesion under adverse conditions is essential. Anti-rusting and anti-scuffing must also be considered.

Hoists: Chain, Pneumatic and Electric

These appliances are essentially overhead materials-handling equipments and as such make used of the third dimension by the utilization of 'air rights'. In so doing they may provide for either vertical or vertical and horizontal movement, over fixed paths, or limited or wide areas. Thus they may be located to give direct lift over the same area and might be so used if required only for the loading and unloading of wheeled transport. They are, however, usually installed to service a limited or wide area. In the former case they would be combined with a pillar, cantilever, interlocking or bracket jib to form a job crane. With wall mounted equipments the area serviced is generally an arc described by the range of the swinging job, whilst with a column jib crane, the area will be a circle whose radius will be the swinging jib. An interlocking jib crane is used to extend the travel of a monorail hoist by providing a stationary extension of trackage. Another type consists of a rigid jib or arm extending out from the wall at right angles, and is moved along the wall on rails. A less limited area of movement is provided by hoists suspended from monorails, but here the normal application is along a fixed path.

Chain Hoists

These are the simplest of the mechanical hoisting devices. They are of four general types; differential; spur-gear; screw or worm gear; and ratchet lever. The differential hoist is, in turn, the simplest of the chain hoists and is intended for light, intermittent service. The spur-gear hoist, most efficient of chain hoists, raises the greatest weight with the least effort, is intended for general purpose service and is recommended for maximum durability, ease of operation and speed. While not as efficient as the spur-gear hoist, the screw hoist is light, portable and well suited to light service especially when speed is not vital. For work such as installation of machinery and equipment, emergency repairs and

general rigging, the ratchet lever hoist is extremely useful in both the horizontal and vertical positions.

Pneumatic Hoists

These are of two types; cylinder and air-motor. Both types operate by compressed air, are economical to instal and use, and provide smooth, accurate control of the load. Cylinder hoists may be either single or double acting. A single-acting hoist is operated by admission and exhaust of air on the stuffing-box side only. Thus there is a variable pressure on the stuffing-box side and atmospheric pressure on the opposite side of the piston. A more accurately controlled hoist is obtained by means of an air balance as provided in the double-acting type.

Air-motor hoists, ranging in capacity from ½ to 10-ton, require a greater initial investment than cylinder hoists, but are as economical to operate and maintain. The motor is totally enclosed and free from the effect of heat and dust. An automatic brake holds the load at any position, even when the air supply is shut off. If the hoist is supported on a trolley, the air line can be disconnected and the hoist moved to a new position without releasing the load. Air lines on a movable unit, however, are generally cumbersome and unhandy to instal and use. The air-motor usually operates at a pressure of 80 lb/sq fit, but will operate at a lower or higher pressure at a correspondingly slower or faster speed.

Electric Hoists

These range in capacity from 1/8 to 20-ton, have a far wider application than chain or air hoists when high speeds are required for economic operation. They are designed to meet varying needs in operation and are furnished with one or two motors, single or multiple-speed control, and push-button, pendant-rope, outrig or remote operating features. They are also available for use with either direct or alternating current. The DC motors are series wound, whereas the AC motors are of the high-torque, polyphase, induction type with either wound-rotor or squirrel-cage winding. Power from the motor is transmitted to the grooved winding drum through reduction gears. The grooved drum carries a single layer of steel wire rope or cable which is dead-ended to the frame of the hoist.

Two brakes, mechanical and electrical, should be provided on

electric hoist. A mechanical brake, of the multi-disc or worm-gear type, hold the load when the motor is at rest and prevents excessive speed in lowering the load. A multiple-disc brake can be adjusted to act whenever the load tends a descend at a speed slightly greater than that corresponding to the speed of the motor. The electric brake, also of the multiple disc type, is operated by a solenoid. When the current is interrupted, the brake acts unless held off by a current flowing through its windings. Either brake has sufficient capacity to support the full load.

Humidity

The water vapour mixed with dry air in the atmosphere. Absolute humidity refers to the weight of water vapour per unit volume of space occupied, expressed in grains or lb/cu ft. Specific humidity refers to the weight of water vapour in pounds carried by 1 lb of dry air. Relative humidity is a ratio, usually expressed in per cent, used to indicate the degree of saturation existing in any given space resulting from the water vapour present in that space. Relative humidity is either the ratio of the actual partial pressure of the water vapour in the air to the saturation pressure at the dry-bulb temperature, or the ratio of the actual density of the vapour to the density of saturated vapour at the dry bulb temperature. The presence of air or other gases in the same space at the same time has nothing to do with the relative humidity of the space.

Hydrocooling

The field heat of vegetables can be removed by immersion in chilled water with an improvement in the freshness of the produce.

Immersion Freezing

See CHILLED AND FROZEN PRODUCE.

Industrial Trucks

A substantial part of industrial, distributive, and other commercial activity requires more flexibility and mobility of equipment for the transportation of materials than is provided by fixed-path handling plant. This need is fulfilled by different forms of industrial trucks. Using these, horizontal or a combination of both vertical and horizontal movements may be achieved. They

offer a flexible method of handling materials for intermittent moves, regardless of the limits of any one building or bay, uniformity of lands and rates, and cross-traffic. There are two main groups of industrial trucking systems, these employing, respectively *(i)* hand trucks, and *(ii)* powered trucks and accessories (*which see).*

Insulation

The function of insulation is to retard as much as possible the flow of heat into refrigerated spaces. The more efficient the insulation is in performing this duty, the more easily and economically can the desired low temperatures be maintained. The best heat insulator is a vacuum, and the next best is probably a gas such as air in a completely still stage. There is no air circulation due to natural convention and heat transmission from this cause is therefore eliminated. Insulating materials such as granulated cork, or slag wool, sub-divide the air space into cells so minute that convection, though not entirely prevented, is greatly reduced and ceases to be important. This is a consequence of surface resistance to the motion of the air, and of the smallness of the temperature difference between opposite cell faces. In addition, the interposition of material between two walls greatly reduced the transmission by direct radiation.

It is, however, important that the insulating material absorbs a minimum amount of moisture, for one reason that the absorption of moisture substantially increases the conductivity of the material, *i.e.*, from 50 to 100 per cent. This property is particularly important in the case of surfaces to be insulated that are below the dew-point of the surrounding air. In such cases, due to vapour pressure difference, it is necessary to seal the surface of the insulating material against the penetration of water vapour which would condense within the material, causing a serious increase in heat flow, possible breakdown of the material, rotting of woodwork grounds and corrosion of metal surfaces.

Insulants in common use include cork, slag wool, cellular expanded rubber, glass wool and aluminium foil. Some properties and applications of each of these is as follows:

Cork: This low-conducting, non-hygroscopic material, in particular cork slab baked and moulded cork, has long been accepted as possessing desirable characteristics for cold storage

work and, despite the many available alternatives, is still widely employed. The slab cork, which has a thermal conductivity of .34 Btu/in/sq ft h°F (*i.e.*, k value) is usually erected in two or more courses laid in cement mortar or asphalt. Subsequent courses have their joints (broken and are fastened with wooden skewers driven obliquely into the preceding course. Finishing of walls and ceilings may be by a cement plaster or an asphalt emulsion, to which is applied a coat of aluminium enamel or two coats of white enamel. The floor insulation needs more protection. A granolithic finish, carried some 5 or 6 in up to the side walls, laid on top of several inches of good concrete, is frequently employed.

Moulded cork covering for pipes and fittings is made up with the desired thickness, and it comes in half sections. These are fastened with copper wire, the joints being carefully filled with corkfiller or cement and the outside painted with an asphalt paint. The important point is to ensure at all times that there are no cracks by which water can get into the insulation. At times it is desirable to add to the covering for pipes and moulded fitting a waterproofing jacket of two-ply roofing paper or a stock 'canvas' strip wound spirally and painted with enough asphalt paint to saturate it.

Slag wool: Available as a loose fill and in quilted, mat and slab form, all of which have a k value of 0.30. When packed at densities less than 10 lb/cu ft the loose material is liable to settle down, leaving air spaces through which heat can leak fairly readily.

Cellular expanded rubber: Cellular expanded rubber possesses very low conductivity (a k value of 0.28), withstands vibration and the action of water. It is light in weight and has a low ignition point.

Glass wool: Low conductivity (a k value of 0.30) and freedom from capillarity are desirable properties of glass wool. Additionally, it does not disintegrate under the action of vibration, its density does not change with vibration and it is fire, rot and vermin proof. The material is available in loose, quilted, mattress and slab form.

Aluminium foil: Crumpled aluminium foil lowers heat transmission by reducing its radiant and convective components. As is well-known, the true conductivity of air is less than any commercial insulating material, but radiation and convection are important additional factors. Air spaces ½ in thick or less separated by paper reduce convections, but radiation is still a large factor. If the paper is replaced by bright metal the radiation factor is

reduced and if this is replaced by crumpled aluminium foil both conduction and convection are also reduced, *i.e.*, areas of contact are lessened and the already small air space is broken up into a number of smaller spaces. The resultant k value is 0.3. The foil tarnishes with time, it forms an oxide coating, but this does not appear to affect its emissivity value, which remains constant at 0.1 or less. Other desirable features are moisture, odour and fire resistance and proof against rot and vermin.

Integration with Layout

The factory building, plant layout and materials-handling are essential factors for consideration when arranging for increased productivity. When a new building is being designed, comprehensive plans should be made before the final decision on building design and layout. In existing factories, improvements in materials-handling may often be effected by rearrangement of machines and the purchase of new equipment. Light and medium weight machinery should be installed wherever possible so that quick and effective rearrangement can be made at low cost. The ability to modify the layout by regrouping production machinery promotes better work flow. It should always be fully appreciated that:

(1) Mechanized handling must be successfully integrated with the whole productive system—the problem should not be dealt with in isolation.

(2) Handling operations should be planned and systemized in the same way as direct production problems—to suit the needs of the individual manufacturing units.

(3) A detailed study of the whole of the handling operations, together with a survey of the existing layout of process plant should be undertaken.

Furthermore, although the primary function of materials-handling equipment is to move materials; if used solely for the purpose of moving materials, and products from one location to another, its usage would, in many cases, not be justified. Properly used, the science of materials-handling may be regarded as a valuable production tool from which many benefits may be secured, in addition to effecting transportation duties with minimum labour and time wastage.

The proper approach to the problem is to realize fully that although its primary function is movement of materials, the equipment should be installed in such a manner that it can be used to perform or aid some other function whilst it is moving materials from one place to another. Additional value can thus be secured from the investment. As long as material must be moved from place to place, it is economical to do something on it. Alternatively, as long as work must be performed on the material, it might as well be moving toward its destination at the same time.

Two major steps to be considered in the development of a materials-handling project include the collection of data on the materials to be handled and the conditions under which movement of these materials is to be effected. Equipment must tentatively be selected for integration into the provisional layouts; of a type that permits ease in fitting the various handling operations to be performed to the volume of activity and also to meet the specific requirements of different processing sections.

Handling activity comprises (1) handling operations, (2) equipments employed, (3) volume of operations. The handling operation should include for starting point, travel and stopping point. Primarily, it should be fully appreciated that the full cycle of operations must be accomplished with a speed and efficiency ensuring that all productive equipment operates at maximum capacity. A decision must also be made at the onset as to whether the materials are to be moved horizontally or vertically, or by a combination of horizontal and vertical operations. The required amount of stock-piling, loading and unloading should again be carefully studied; a minimum in each case should be the objective.

Starting point can be regarded as meaning the point of initial movement between work-centres; commencing with the receipt of raw materials. Avoidance of unnecessary movements of each item, particularly vertical movement, if effected manually, is very desirable here. It is for this reason that every consideration is given to the installation of conveying equipment of one kind or another to link-up production machinery; when the sequence of operations can be planned for line-flow. When a machine line is so interlinked by a conveyors, it represents, in effect the first step towards transfer machinery, or full 'automation'.

Another feature is made very obvious in the materials-handling throughout a factory—it is seldom that the same type of handling

equipment will cater for the entire handling needs. For a start, the product invariably changes shape, weight and size as it progresses through the full range of processing operations. Secondly, whilst the earlier stages of processing can usually provide for the continuous movement of materials, the product, as it gains weight and size may only need moving at infrequent intervals. Thus in many cases, resort may be had to a number of types of handling appliances; selection being based upon the right type of equipment to suit the projected work. Each equipment is then integrated in the overall handling system—or combination of systems.

The distance moved between starting and stopping points depends largely upon production routing, but here often the relocation of machinery can sometimes be effected to reduce the distance materials have to be moved without detracting from production efficiency. Conditions governing stopping-points are similar to those appertaining to starting-points. They should be arranged to effect maximum economy at work-centre. In all cases, a handling system should be planned in such a manner that workers are able to stay at their machines or work-stations and keep producing while material is brought to them and removed in quantity.

It is also important to pay attention to the integration of the industrial-truck system with other systems, if one of the other systems is best adapted for part of the production flow. Typical examples my be found where a number of small items are produced and then packed, resulting in a series of small production lines. An analysis of these production lines may show that in some cases, especially where the time required by successive operations is substantially the same, some form of light conveyor may be best suited. In other cases, stillage-boxes, moved from operation to operation by hand-lift truck, or live (wheeled) stillage boxes, also moved by hand, may be the best selection for the purpose.

In all of these cases, the pieces of material usually must be handled by the production operator in order to put them through the process; and the main requirement is to arrange the delivery and movement of the pieces so that no additional motions are necessary. For example, delivery may be by means of stillages arranged to bring the pieces within easy reach so that the operator takes them from the stillage and puts them into the operation with one motion. Similarly, he should be able to remove the piece from

the operation and place it on to the outgoing stillage in one motion. In the use of a conveyor, the same motion-saving should be possible.

Finally, when the point of packaging is reached, the ideal arrangement, again, is one which requires no motions for purposes of handling which are not already necessary for purposes of production. For example, goods coming from a wrapping machine, or cans or bottles coming from a filling and sealing machine, usually move on to a conveyor to a station for packaging into cartons, which, after sealing, are piled on to stillages or pallets. In none of these instances is the ideal arrangement completely satisfied, but, once the cartons are on stillages or pallets, they can be handled through stock and shipping-rooms without further hand motions.

In some cases, due often to plant geography, a haul is necessary from the end of one series of processes to another bay or building for which the industrial truck may be found best suited. This will often influence to some extent the choice of the handling through the series. Good practice is the use of stillage-boxes or live stillages which can be picked up at the end of the series, one, two, or three at a time, by lift- or fork-truck. If the finished product has to be stowed in out-going carriers in less than power-handling units, the best that can be done is to take the stillages or pallet loads as close as possible to the stowing point and then unload by hand.

Jacketed Stores

The cooling of freshly-slaughtered meat as rapidly as possible in a current of refrigerated air quickly reduces the temperature at the surface. This not only inhibits the growth of micro-organisms, but tends to reduce evaporation. The latter, and thus the weight loss following slaughter, is also influenced by thermal radiation and this becomes noticeable especially during long-term storage of unprotected deep-frozen foods such as meat and fish. If these are stored near a warm external wall of a store, radiant heat raises the temperature of the surface of the stored goods and then the partial pressure of the water vapour at that surface. On the other hand a cold surface in the vicinity, such as a cooling element, lowers the surface temperature and leads to a smaller vapour pressure differential.

Since the weight loss is always proportional to the partial pressure differential, the advantages offered by stores having

double walls, or 'jackets' through which refrigerated air is circulated are readily apparent. The stored goods are surrounded at all times by surfaces at a lower temperature than themselves, all refrigeration and ventilation equipment is eliminated in the store proper and the conditions needed to prevent 'freezerburn' are easily attained. Stores of this type were first built in Canada, whilst experiments in the U.S.S.R., indicate a weight loss of frozen meat of only 0.78 per cent per year held in a jacketed store at –17 to –18°C (1.4 to –0.4°F) and 96 to 97 R.H. It is, however, stressed that the primary object of the stores is to dissipate heat entering from outside: the foodstuffs are brought down to the required storage temperature by high-speed cooling or freezing tunnels. Provision is, however, also made for slots in the side walls to permit direct circulation of refrigerated air through the store, as might be required after ventilation or when goods whose temperature has risen during transport are taken into store.

Liquid Receivers

Liquid receivers are often provided with refrigerating installations so as to provide a storage space for an excess of refrigerant, to ensure that only the condensed refrigerant shall pass through the regulating valve, and also to provide storage space if it becomes necessary to pump out a circuit in order to effect repairs. They should be of ample size, and their use, especially in small plants, will prevent the need for the periodical addition of small quantities of refrigerant.

Live Storage

Increasing use is being made of 'live' storage, a condition only attained when all materials are subject to non-manual movement and dead storage is completely eliminated. Very few products lend themselves entirely to this treatment, but with all, adoption of the principles of live storage offers a means of cost reduction. Use is not restricted to any one particular type of handling equipment, or combinations of equipment, neither is it necessary for storage to be effected conventionally at the termination of the production line. Storage can often form an integral part of the processing line, or of the actual process. Examples are the conveyorized systems used in the cooling of bread, fermented foods, cakes and confectionery.

Through flow with minimum buffer stock is comparatively simple in despatch stores and warehouses when only one or a few products are handled, but complications arise when despatch is subject to order selection or 'picking'. One solution is to resort to 'perimeter supply', in which live storage pallet racks are used to surround a work area in a perimeter supply pattern. This principle keeps all stocks and materials outside the work area.

Lloyd's Rules

Many owners of public cold stores, especially those situated at ports, have had their installations surveyed by the engineers of the Committee of Lloyd's Register, which carries with it, if the installation is approved, the privilege of refrigeration in the Society's Register Book. In brief, Lloyd's requirements are that the refrigerating machinery shall be of approved construction and capable of maintaining a temperature of –9.4°C (15°F) simultaneously in all the insulated chambers when running not more than 18 hr per day. Not less than two compressor units are to be installed, and each is to be capable of fulfilling the above requirements. Each compressor must be driven independently or the power mechanism must be in duplicate. Various hydraulic and other tests are specified for such parts of the machinery as compressors, condenser coils, evaporators, headers, etc.

The insulation has also to be of approved type and standard, while various specifications are made as to equipment, spare gear, periodical surveys, etc.

Maintenance

The step by step recommendations for ensuring that mechanical handling equipments are properly maintained are:

(1) Before purchasing equipment determine the duties it has to perform, and ensure whether or not it is suitable for the projected work.

(2) Before purchase ascertain the probable maintenance costs.

(3) On purchase, secure full preventative maintenance instructions.

(4) Embody the maintenance instructions in standing procedures, and make certain that those concerned comply with these instructions.

(5) Schedule the preventative maintenance.

(6) Train maintenance and operative personnel in preventative maintenance procedures.

(7) Ensure that the equipment is not used under circumstances conducive to damage.

(8) Keep records of maintenance work effected on each equipment.

(9) Keep record of maintenance costs.

The servicing of well-designed and constructed conveyors and elevators is so very simple that no elaborate maintenance instructions, lubrication charts, etc., are in any way necessary. It is, however, stressed that fairly frequent intelligent inspection is far more useful than neglect for long periods followed by excessive and unnecessary maintenance.

It is recommended that all bearings, where necessary, are greased once every three months and, at the same time, motors, reducing gears, etc., should be inspected for alignment and replenished with oil as required. Every few days the equipment should be inspected to ensure that the conveyor belt is tracking accurately throughout its run and adjusted if not so doing. Correct alignment of idlers, terminal pulleys and paralleling of shafts is essential.

Chain elevators and conveyors are advisedly according the same lubrication treatment as belt conveyors, except than if no automatic lubricators are fitted the main lifting and haulage chains should be oiled and greased every three months. They do not require, as a rule, to be inspected for correct running and frequently as belt conveyors, but an inspection for running once a week or once a fortnight is suggested. The operator of a conveyor belt should look at his charge with the same critical eye as the owner of a new car. The hazardous period in the life of a belt is immediately after installation. The causes of belt injury are many and vary to some extent with the type of materials handled. They can, however, usually be remedied.

Field repairs on fabricated rubber conveyor belts are often carried out at the same time that splice work is effected; vulcanized splices are recommended as the safest, and ultimately the most economic method of joining belt ends. Minor cover repairs can,

nevertheless, be made on conveyor belts by maintenance personnel, without previous belt repair experience, by means of a self-curing 'two-way' rubber dough. This material will not produce a repair job as satisfactory as one vulcanized under heat and pressure, but it will help to close 'wounds' against contamination.

Steel-band conveyors are in many ways similar and require comparable attention to rubber belts. There are, however, one or two features which are a little different; one of these being that the joint can be either welded or more normally riveted. The welded joints in stainless bands can now be made in this country, but in the carbon steel bands these are still made in Sweden owing to the need for heat treatment afterwards. Periodical inspection of the joint will indicate any possible loosening of rivets.

If and when a joint fails this usually occurs on one side of the joint, and not across the line of rivets. The previous joint must be cut out, removing as little sound band as possible, in order to avoid shortening the band more than is necessary. If, however, the old joint is a good one and has not parted, much time can be saved by punching a new row of holes on either side and as close as possible to the old band ends; being careful to see both lines of holes are perfectly parallel and correctly squared transversely. It is stressed that successful operation of the conveyor very largely depends upon the care exercised in making the joint. There is no reason why a joint should not be lined up and made satisfactory in two to three hours.

The tracking effort of the bands is largely dependent upon the terminal drums, which are machined flat curves to exert guidance in alignment. Should the band show any tendency to do otherwise, the end bearings are in need of adjustment. In normal operation the band shows a slight and gently floating motion to each side of both drums and idlers.

Should a band tend to float excessively, or erratically after having been in satisfactory operation, it is advisable before altering the adjustment of the terminal bearings to see that the terminal drum faces are quite clean and that there is no material adhering to the inside faces of the band; either of which will cause erratic float. To keep the drums clear under normal conditions of operation, cleaners are fitted to both tension and drive drums, also scrapers to clean the carrying and inside surface of the band. These should be inspected at regular and frequent intervals to ensure that they

are bedding down properly, and replaced when worn. Periodical greasing of all bearings as for normal rubber belt conveyors is, of course, necessary and should, with the inspection duties, be made the responsibility of one man.

There are many other types of floor and overhead conveying systems of simple and complicated construction; hand and power operated. All of these should be subject to servicing and maintenance in accordance with the marker's instruction manuals. Often the latter get overlooked and an abbreviated system of servicing is substituted. This is not to the best interest of either the user or the manufacturer of the equipment. This dictum applies even to hand-operated pulley blocks—and especially to power-operated equipment of this design, in which considerable care has been given to the simplification of servicing and maintenance. It is stressed that neglect of these features leads rapidly to inefficient and unsafe operation, and a shortened useful working life.

To keep a powered-trucking system operating efficiently it is essential to instal a regular inspection and maintenance service, as set forth in detail by maker's lubrication and service manuals. This is preventative maintenance. To implement this the following basic servicing periods for powered trucks should be observed.

(1) *Eight-hour inspections:* In addition to the normal preparation for daily work routine the driver should test steering gear, brakes, hoisting mechanism, controllers, tyres and other visible parts. Any defects noted should be reported immediately.

(2) *Forty- to sixty-hour servicing:* This includes washing and cleaning thoroughly and complete lubrication as recommended by the manufacturers.

(3) *Semi-annual check-ups:* Wheel bearings should be repacked. Chains on hoisting devices should be cleaned and inspected. Brake linings should be examined. Other parts to be checked include the steering gears, axles, wheels, pins, yokes and ball connections.

The maintenance of battery-electric trucks includes the daily charging of batteries, which requires from 6 to 8 hr. If the trucks are operated for only one shift, the batteries can be charged without removing them by installing outlets in he charging room where the trucks are parked. If the trucks need spare batteries changed at intervals, the charging room is laid out for batteries only. Changing of the batteries can be accomplished by using roller-top tables mounted on castors to carry the batteries, hoists

suspended from monorail arranged as jib or travelling cranes, or benches of the same height as the compartment stillages.

Batteries may be charged with direct or rectified alternating current. Direct current may be employed with suitable control equipment or motor-generator sets. Multiple-circuit units utilizing alternating current and a constant voltage generator charge a number of batteries at once. By use of an ampere-hour meter each battery can be automatically disconnected from the circuit when fully charged and the motor-generator set can be automatically shut-off when the last battery has been disconnected.

All trailer equipment should be lubricated and inspected for damage at regular intervals. With the operation of a large number of trailers in a plant it is difficult to determine what units have, or have not, been greased and inspected, as all, or any large portion, of the fleet cannot be withdrawn from operation at any one time. When the individual trailers are withdrawn in small lots, a record of each trailer can be kept by a number.

The simplest way to assure the greasing and inspection of the whole fleet at any set period is to place a round paint spot about the size of a penny on the front of the trailer frame, close to the coupler. Use a distinguishing colour for each greasing on inspecting period. As each succeeding period comes around, cover the point spot for the preceding period with that colour selected for the following period. The paint spots are easy to see, and trailers in operation without the correct colour paint spot can easily be withdrawn from operation. There should be at least four periodic inspections and greasing for an operating year. If the trailers are in continuous 24-hr operation, the number of periods should be increased.

Materials Handling

Materials handling concerns the transportation of all materials into and through a factory, through manufacturing processes, packaging, storage and despatch. To follow the flow pattern properly, it incurs more than transportation in the accepted sense of the word, that is the carrying or moving of materials from one place to another in the horizontal plane; it must provide for lifting, moving, tiering and stacking. Handling costs money, which once spent adds no value to the product. Therefore, the adoption of modern materials-handling methods and equipment endeavours

to eliminate this source of industrial waste, effecting at the same time indirect or 'hidden' cost reduction. This accrues through the agency of a smoother materials flow resulting in less lost time of skilled process operations and production machines, fewer accidents, less materials and equipment damage and economies in production and storage areas.

As no other factors have too great an effect in reducing production costs and increasing production efficiency, the materials-handling system should receive primary consideration in the planning of manufacturing cycles, factory layout and flow of materials. The ideal situation would be one in which raw materials enter one end of a factory, move through processing in a straight line and leave as finished products at the other end; all with a minimum of back-tracking, cross-hauls and number of routes. The nearer these conditions can be attained, the less it will cost to handle the materials.

It must, however, be fully understood that the design of a materials-handling installation cannot be effected by 'hit and miss' methods. Neither is 'mechanical handling' the absolute solution of all materials movement problems. Instances arise wherein manual handling may prove more effective and economical. Further to this, selection of the proper handling equipment to suit manufacturing conditions is most important, whilst slight modifications in plant layout, or in the actual process, might well result in far reaching handling economies. It is only by the most painstaking analysis and evaluation of all factors relevant to the application that materials-handling problems can be successfully solved. Similar principles apply in all cases, but no two applications are exactly alike.

Principles of Materials-handling

Each time materials are lifted or laid down, piled or unpiled, loaded or unloaded, transported vertically or horizontally from one position or location to another, fed into or removed from a process, placed into or removed from storage, or moved in any way whatsoever, they undergo 'handling'. Applied to a manufacturing plant, the objectives of materials-handling are to transport materials continuously from point to point, without retrogression and with a minimum of transfers, and deliver them to their appropriate workplaces or production centres in a manner

which will avoid congestion, delays, and further unnecessary handling. In so doing, the selected system, or combination of systems should *(i)* control handling costs and *(ii)* serve production with the utmost efficiency.

Regardless of the means employed, materials-handling makes use of two basic motions only—horizontal, vertical or a combination of both. The horizontal motion, as accomplished through manual effort or mechanized conveyance, provides a transfer of materials from where they are at the moment to where they are needed. While this is the most simple basic motion, it is also the most frequently used in industrial operations. Seldom is the horizontal motion possible unless preceded by a lifting and followed by a lowering action. There are few better opportunities to save time and effort than when manual vertical lifting and lowering are eliminated in handling material. Lift, carry, and deposit are the essentials of the combination motion; along fixed and non-fixed paths of material flow.

Handling activity comprises *(i)* handling operation, *(ii)* equipments employed and *(iii)* volume of operations. The handling operation includes starting-point, travel and stopping-point. The full cycle of operations should be accomplished with a speed and efficiency ensuring that all productive equipment operates at a maximum capacity. A decision must also be made at the onset as to whether the materials are to be moved horizontally or vertically, or by a combination of horizontal and vertical motions. By careful motion study it is often possible to reduce the number of basic motions required throughout the flow pattern, minimize delay factors, eliminate manual handling and to shorten paths of travel by rearrangement of process equipment. Within this structure time study performs two main services. First, it provides an analysis and breakdown of the elements that go to make up an operation, and second, it gives an accurate measurement of the importance of handling elements in terms of time required for their performance.

The methods used for the handling of materials from point to point will depend upon such factors as the physical characteristics of the materials, distance, and time. The physical characteristics of the materials are most important. These include fragility, corrosive and combustible qualities, resistance to contamination, shape, size, weight, and whether in solid or liquid form. Each calls

for different treatment, involving considerations as to whether the materials is to be moved in bulk or by individual units, and if the materials may be moved continuously or intermittently. Changes in the physical characteristics of materials during processing will also have a direct bearing on the handling methods employed. Thus, in most cases, a number of handling appliances will need to be used, selection being based upon the right type of equipment for the projected work. Each equipment is then integrated in the overall handling system or combination of systems and in turn integrated with the whole production system.

Table 2
Materials-handling Objectives

Objectives		*Principles and Practices Involved*
1		2
Lower Unit Materials-handling Costs		
Eliminate unnecessary handling	1.	Proper planning.
	2.	Replace existing materials-handling equipment with a better type whenever the new equipment will yield greater efficiency or savings.
	3.	Complete movement of materials on one trip.
Reduce rehandling time to a minimum	1.	Deliver materials to the right place the first time.
	2.	Complete movement of materials on one trip.
Handle as many pieces as possible in one unit	1.	Use unit packages.
	2.	Use stillages, pallets, gondolas or racks.
Reduce Production Time		
Avoid delays of process or machine operations caused by waiting time	1.	Ensure that the capacity of materials-handling equipment is as nearly as possible equal to that of plant and labour; to avoid bottlenecks.
Maintain a continuous uniform, maximum rate of movement of work	2.	Equip process lines with variable speed drives to permit adherence to work schedules as the latter are changed.
	3.	Use conveyors where practical to carry materials to and from workplaces.
	4.	Provide for automatic processing of products.
Reduce Overheads		
Reduce employment of non-productive labour	1.	Co-ordinate handling in a manner that releases non-productive manpower for productive operations.
	2.	Install materials-handling equipment that eliminates needless walking, reaching, lifting, moving.

(Contd.)

1	2
	3. Prevent accidental damage to materials and products in transit, by using the right kind of equipment.
Co-ordinate all materials-handling systems	1. Integrate the various systems to operate in synchronization wherever possible.
	2. Install systems capable of aiding or supplementing each other.
	3. Purchase equipment which is as near standard as possible to permit, if necessary, its uses for purposes other than originally intended.
	4. Have some variety so as to be able to meet all situations.
Conserve floor space	1. Have enough equipment to correlate materials-handling with production schedules and prevent excessive stock storage in production areas.
	2. Install materials-handling equipment which will carry materials in a position to save space (conveyor racks, up-enders, etc.).
	3. Use materials-handling equipment which requires no fixed floor space (overhead systems and industrial trucks).
	4. Study all materials-handling problems in relation to plant layout and *vice versa*.
Worker Accident and Fatigue Prevention	
Install materials-handling equipment whenever it can replace heavy physical labour in the movement of materials	Whenever a worker has to (1) lift anything from the feet to above the head, (2) lift more than 40 lb from the feet to shoulder height, (3) lift more than 60 lb from the feet to the waist, (4) lift more than 75 lb from the feet to the knee height, (5) stand in one place steadily moving materials for more than 30 min, (6) move material sideways for more than 5 ft, and (7) whenever a worker, or group of workers, although moving around in a small radius, must move more than 10 tons of materials per hr.
Install safe handling equipment	1. Ensure that all equipment has all the necessary safety features to protect workers from accident.
	2. Fit guards to all existing equipment.

Although the primary function of materials-handling equipment is to move materials its full potential would not, in many cases, be fully realized if used solely for this purpose. The proper approach to the problem is to appreciate fully that although its primary function is movement of materials, the equipment

should be installed in such a manner that it can be used to perform or aid some other function while moving materials from one place to another. Additional value can thus be secured from the investment. As long as material must be moved from one place to another, it is economical to do something to it which is essential to the process at the same time. Alternatively, as long as work must be performed on the material, it might as well be moving towards its destination meanwhile.

Classification

Many efforts have been made to classify the princples of materials-handling, but unfortunately no specific answer can be given which will embrace the wide range of specialized considerations which may apply to an individual industry. The most important and widely applicable principles are: *(i)* needless handling costs money but cannot add value; *(ii)* handling should be correlated with production; *(iii)* all handling systems should be integrated; and *(iv)* handling equipment, like production equipment, should be obsoleted and replaced whenever greater efficiency can thereby be obtained. A further principle applying to power handling, sometimes called the principle of the unit load, states 'The more pieces, pounds or tons of materials it is possible to combine in one unit and move without breaking load, the lower will be the cost per piece, pound or ton, and the shorter the time'.

One useful method adopted to give an overall picture of the principles of materials-handling comprises the breaking down of the main objectives into several more specific objectives and the coupling of these known principles, in the manner shown in Table 2.

This forms a useful guide to attaining the desired objectives in planning a plant layout.

Mechanical Refrigeration

While mechanical refrigerators differ in the methods used for compression of the refrigerant vapour, they are fundamentally similar. They operate on a closed-cycle, vapour-compression system and basically comprise a compressor, condenser, expansion valve, and evaporator or cooler, together with connecting pipework. Low-pressure saturated or slightly superheated vapour is drawn into the suction of the compressor. It is then compressed

adiabatically to a vapour pressure such that the corresponding saturation temperature exceeds that of whatever cooling medium is available. After discharge from the compressor, the superheated high-pressure refrigerant vapour is passed through the condenser in which it first loses superheat and then condenses, leaving the condenser as a liquid at the compressor discharge pressure (assuming an ideal system) and at the corresponding saturation temperature, or if some subcooling of the liquid occurs, at some lower temperature.

Since the pressure in the condenser is high and that in the evaporator is low, the liquid refrigerant is discharged into the evaporator through a throttling or expansion valve so adjusted that the rate of flow of refrigerant to the evaporator as equal to the rate of evaporation at equilibrium conditions. This operation lowers the temperature and pressure of the refrigerant and, at the same time, causes it to evaporate partly; hence the refrigerant will leave the expansion valve as a very wet vapour and at very low temperature. This wet vapour absorbs latent heat from the air or substance being cooled as it evaporated still further whilst passing through the evaporator. The refrigerant leaves the evaporator in the state received at the compressor suction, completing the cycle.

From the foregoing it will be seen that the refrigerant is constantly circulated through the system, constantly condensing and re-vaporating. In so doing the refrigerant gives out latent heat to a cooling medium during condensation and absorbs latent heat during its passage through the evaporator. The mechanical or vapour compression refrigerator can thus be regarded as a latent heat pump.

Compressors

The compressor is the heart of the vapour compression system and those in common use are:

(i) Reciprocating compressors using a volatile refrigerant. They may be of either the single-acting or double-acting type, the latter having approximately twice the capacity of the former with the same diameter of cylinder and length of stroke. Arrangements can be made for simple or multi-stage compression, the latter providing for intercooling between stages, whereby the compression process can be made to approach in performance the isothermal rather than the isentropic. In certain circumstances

dual compression is advantageous.

(ii) Rotary compressors using a volatile refrigerant. These are also positive displacement units, but employ rotating elements such as the blade, gear lobe and screw type. In the case of the first, rotation of the shafts and blades traps the refrigerant vapour between the moving elements and the case and delivers it to the condenser at the required pressure. The rolling together of the impellers in the gear, lobe and screw types prevent the return of refrigerant vapour to the low pressure side of the system. The rotary screw compressors, which are used extensively for food refrigeration application, consist basically of two intermeshing, helically fluted rotors mounted in a casing. The male rotor, with four lobes, corresponds to the pistons and the female with six lobes to the cylinder of a reciprocating compressor. Drive is transmitted to the male rotor and lining gears maintain the relative position of the rotors and prevent actual contact. Thus, the rotors do not suffer mechanical wear and, with an oil-seal, the volumetric efficiency of the units is maintained throughout their life. Resort is had to multi-stage operation to give the compression ratio needed for low temperature work.

(iii) Centrifugal or turbo compressors using a volatile refrigerant, or, sometimes, water as a refrigerant. Freons are now extensively employed, but the machines may be run with other refrigerants of high molecular weight, enabling them to be used for low temperature installations. They are also built for simple or multi-stage compression. Since centrifugal units do not have positive displacement they can be easily controlled by throttling either the suction or discharge, thereby permitting simple variation in capacity at fixed speed. They also permit delivery of a variable displacement at constant speed and with an approximate constant ratio of compression.

Condensers

The condenser consists of a closed system cooled by water or air into which the gaseous refrigerant is forced by the compressor. Here it gives up its heat of compression and its latent heat of vaporization and returns to the liquid state. The various types in common use are:

(i) The atmospheric condenser which is usually mounted on an exposed roof sheltered from high winds by louvres, and

compresses vertical banks of horizontal coils through which the refrigerant flows. The coils are located above an open tank and their external surface kept wet by sparge pipes supplied with water by a pump installed near the tank. Unless the surrounding air is fully saturated with moisture, evaporative cooling takes place on the surface of the condenser. A small quantity of water, lost by evaporation and splash, calls for a corresponding amount of make-up water from the mains.

(ii) The shell and tube condensers. These are two types; the horizontal shell and tube and the vertical shell and tube, both of which comprise a cylindrical shell housing tubes expanded into tube plates. In the vertical condenser the water flows inside the tubes in a water film holding to the surface by adhesion and to some extent by the initial swirl where the flow is caused by gravity with one laminar layer flowing past another in viscous flow. In the horizontal multipass condenser the pipes are filled with water, which usually has six or more passes before the condensing water leaves the condenser, and as the flow is controlled by a head of water or a pump the water flow is usually turbulent.

(iii) Double pipe condensers using counter-current flow of the refrigerant and cooling water. The design embodies two concentric pipes arranged in a continuous vertical bank with the water passing through the inner pipe and refrigerant circulating through the annular space in the outer pipe. Economy in cooling surface is a design feature, *i.e.*, this is only about one-third of that required for an atmospheric condenser of equal cooling capacity. Equal quantities of coolant are required because the double-pipe condenser does not have the advantage of the evaporative cooling effect. This is, however, more than offset by operation on the counter-flow principle, which allows the liquid refrigerant to be delivered at the lowest possible temperature. A further advantage is that the unit can be located in the most convenient position relative to the plant-room layout.

(iv) Evaporative condensers which combine in themselves the functions of water-cooled condenser and cooling tower. A casing contains a nest of coils over which water is recirculated by a pump, and through which air is circulated by fans.

(v) Air-cooled condensers, commonly found on smaller machines where the advantages of a liquid heat-transmitting medium are sacrificed to make the unit independent of the water

supply. Coil surfaces are augmented by metallic fins or wire-wound tubes and increased velocity is obtained by means of a fan driven by the motor.

Expansion Valves

A throttling valve of this type located between the condenser and evaporator achieves a pressure reduction with accompanying reduction in the saturation temperature; with consequent evaporation of a portion of the refrigerant. 'Flash' vapour forms during the process of cooling the liquid refrigerant on its passage through the valve. It should, however, be observed that the purpose of the expansion valve is to achieve a drop in saturation temperature and not to achieve expansion. The fact that expansion occurs is a wholly undesirable, though necessary, condition, since expansion is the result of evaporation which, in turn, is due to loss of refrigerating effect of part of the refrigerant resulting from necessary cooling of the remainder. Operation of the valves may be manual or automatic.

Evaporators

The evaporator is the actual portion of the installation in which the refrigeration is effected. In some cases the evaporator is installed actually in the chamber or apparatus it is desired to cool, when the term 'direct expansion' is applied (q.v). In the other method the evaporator, consisting of a series of closely nested coils, is erected in a tank, through which the brine is continuously circulated. The brine, coming into contact with the cold evaporator coils, has its temperature reduced considerably, and as it is passed through the pipe grids in the cold rooms heat is extracted from the atmosphere in contact with the piping. A more modern type of brine-cooling evaporator comprises a cylindrical shell in which the refrigerant evaporates, and tubes through which the brine passes and which are immersed in the liquid refrigerant. Baudelot-type coolers, constructed after the style of open condensers, are also often employed.

Non-condensable Gases

Air is the principal non-condensable gas which finds its way into the refrigerating circuit, and its presence there entails the performance of a considerable amount of unnecessary and useless

work by the compressor. The air usually tends to accumulate in the condenser, and the provision of a purge valve in the top of this part of the equipment is advisable,.

Overhead Chain Conveyors

The overhead chain conveyor is perhaps one of the most useful of handling devices. Compressing a monorail or similar runway, load-bearing trolleys and an endless chain drive, it is a simple, flexible, and economical method of transporting materials from point to point on a fixed line of travel, making overhead space pay dividends by saving floor area, avoiding floor congestion, and permitting straight-line production without costly reconstruction of a building.

Loads are carried by means of hooks, racks, special carriers or suspended trays. The track may be arranged to drop at predetermined points to permit materials to be removed from and placed upon their carriers. Various modifications of the system have been developed, these including load-bearing chains, each link of which is fitted with guide wheels to run in an enclosed track. Semi-automatic operation can be attained on an overhead conveyor by the use of automatic discharge or dumping stations for trays, upending and loading devices, and automatic transfer. The load-carrying hooks or trays can easily be adapted to the automatic devices and may be made to any shape or form required by the load.

Overhead Handling Equipment

Cranes and hoists comprise the best known of the overhead handling equipment. They may be of either the fixed or mobile type, but are generally used to provide for movement of materials intermittently over any desired lines of travel within a fixed area, movement of materials of variable size and weight, and movement of materials regardless of cross-traffic or uniformity of load. Overhead travelling bridge cranes or transporters have a wider application than any other type of crane because of their adaptability to manufacturing processes and their handling of loads in any direction over the width and length of an area encompassed by their runways, without interference with work in progress on the floor and without sacrifice of floor space. Movement of materials is intermittent, but it provides for all handling motions.

Chain, pneumatic, and electric hoists also provide for overhead and intermittent handling. They may be located to give a direct lift over the same area and might be so used if required for the loading and unloading of wheeled transport. For a limited service area they would be combined with a pillar, cantilever, interlocking or bracket jib to form a jib crane. A less limited area of movement is provided by hoists suspended from plain, geared or motor-driver trolleys running on monorails but here the normal application is along a fixed path. Alternatively, a hoist may comprise the lifting element on an overhead travelling crane, so increasing its service area.

Electric hoists have a far wider application than chain or air hoists where high speeds are required for economic operation, while for fast travel and maximum efficiency, motor-driver trolleys are recommended. In many such systems it is advantageous to provide means for the carrier to pass from one track to another. This can be accomplished by a simple latching device that lines up the bridge crane with a spur track or a cross-over. When it is necessary, however, to diverge from a track at an angle, some type of switch is required. It may be a transfer or sliding switch that carries two pieces of rail, one being used at a time; a tongue switch of the two- or three-way type; or a rotating switch or turntable. The switches can be operated from the floor, from the cab of a monorail hoist or telpher or by means of photo-electric cells placed to intercept the line of travel.

One of the most outstanding developments in the utilization of monorail systems is the adaptation of automatic and manual controls to permit the despatch of one or more power-driven trolleys to any point over the system. Loads of various types can easily be controlled so that they move between departments, between floors, and even between buildings where they are released automatically at pre-determined locations (one or more) from which carriers return to the point of origin.

Palletization

The receipt and despatch of materials is facilitated by the pallet-load method of handling, in which materials and components are packed on pallets making unit loads that can easily be handled by a fork-truck. Goods packed thus can be taken from storage, loaded into a common carrier, unloaded and finally taken to

storage or process by a fork-truck in a fraction of the time formerly needed by manual labour. An additional advantage is that storage space can be saved by the ease with which properly loaded pallets can be packed one upon the other by fork-truck, utilizing all available headroom, or 'air rights'.

Pallets for use with fork-trucks are made in single or double face and of wood, steel, wood reinforced with steel, aluminium or fibre board. While steel pallets have a higher initial cost, their longer life and non-warping quality offsets their higher cost. When goods are shipped on pallets, however, the less expensive wooden pallets or the lighter aluminium pallets are preferred. Choice of a pallet, as well as its design and construction, depends on the given service.

Single-faced pallets are generally used for transport, except when heavy loads might cause them to collapse, whereas double-faced pallets are better adapted to service within a plant, especially where tiering is necessary. In either case, the under-clearance of the single-faced pallet and the opening between faces of the double-faced pallet should be approximately 4 in to permit quick insertion of the handling forks. Double-faced pallets may be two-, four- or eight-way depending on the number of ways the forks can enter, as determined by the position of the stringers and blocks used in place of stringers. The upper face of double-faced pallets may be solid or spaced, but the lower face should have standard openings and chamfered edges to accommodate the wheels of hand pallet trucks. Some pallets are made with openings as small as 6 1/2 in, but openings of 8 to 8 1/2 in are recommended.

Wooden pallets may by of either soft or hard woods, depending on the service requirements. Satisfactory soft woods are pine, fir, hemlock, spruce or chestnut, whereas the hard woods for heavy-duty pallets are beech, birch, hickory, maple, cherry, ash, oak or tupelo gum. Three 2 x 4 in stringers, or runners, are needed for each pallet, and the face boards should be 1 in commercial stock from 4 to 8 in wide with the end boards 6 in wide. The sizes accepted as standard for common usage are:

36x36 in	48x36 in	54x42 in	60x60 in
40x32 in	48x40 in	56x48 in	72x36 in
42x46 in	48x48 in	60x40 in	72x48 in
48x30 in	50x44 in	60x48 in	72x54 in

In palletizing the handling system it is highly desirable to standardize a method of assembling unit loads on pallets. Products either regular or irregular in shape can be palletized by tabulating the sizes and working out an arrangement to utilize the entire area of the pallet. If necessary, a blank space may be left at the centre, or an overhang of 4 to 5 in may be allowed if the parts or packages are not fragile. Careful packing is necessary for stable loads and alternate rows may be interlocked to increase stability by placing heavy paper or fibre board between the horizontal rows of packages or by alternating the patterns to avoid columns within the load. The height of stacking on pallets depends on the strength of packages, capacity of trucks, and head-room and floor-load capacity in the warehouse.

It should be noted that stillages stand higher than pallets, by some two to three times. This greater clearance is necessary to permit the use of low-lift trucks. Apart from this distinction there is little difference in design. Furthermore, with both designs a production problem is that of assembly of unit loads. It is time-absorbing if effected manually, offering high labour costs. These are eliminated by the comparatively recent development of the automatic pallet-stillage loader. The machine is designed to accept cases or crates of almost any size, providing that the sizes are not mixed. It is installed at the end of the packing line and as the shipping units are received they are fed on to a loading table by an operator who merely arranges the layer to be loaded. From then on the machine takes over.

By manipulating a push-button the operator initiates the sequence of depositing the layer of crates or cartons on to the pallet or stillage and the lowering of the pallet to receive the next load. This sequence is repeated until the full unit load has been deposited on the pallet whereupon the machine automatically discharges the full pallet and presents an empty pallet in position ready for the next load. The pallet loader is capable of dealing with cases and crates at a continuous rate of between 40 and 50 a minute, building them into unit loads of up to one and a half tons and of varying heights determined by the size of the unit load.

Pneumatic Conveyors

Many products at some stage in their manufacture exist as powders or granules and in this state require to be stored, batched,

blended and delivered to packing stations or to subsequent processes. Pneumatic conveying in these stages offers many advantages over other forms of materials movement in that materials are transported in a pipe system so that the operation is dustless while the conveying lines can follow routes impossible to mechanical conveyors.

Other major benefits are the conveying of different materials in succession without contamination and the movement of a weighed batch without loss from a central dispensing station to alternative points of use. It is, however, desirable that the materials handled are dry and free-flowing, and they should not be easily subject to damage. Medium density systems with a material/air weight ratio up to 50 are almost universally used in the food industry, the conveying air flow being provided by oil-free rotary piston blowers.

Process Dusts

Resort is also had to pneumatic conveying systems in the control of process dusts. The principle of design of pneumatic conveying system is similar for all cases. Thus, either individual systems serving each source of process dust supply, or a centralized system serving all supply points, may be employed. In the latter case, the system is sub-divided into a number of sections, each of which is considered as a separate problem. In the final design each section must, of course, be considered in relationship to the plant as a whole, but in the initial stages of design, individual treatment is both possible and desirable. In general the various sections comprising an efficient exhaust and collecting system of this type are as follows:

(1) Means for receiving dust from the source of supply, usually by hoods. Dust which cannot be collected at the source of generation is dealt with by conveniently placed floor sweep-ups, or sweep-downs if the suction ducting is underground.

(2) The ducting or piping to convey the collected material. An important feature to be considered in any conveying system is that since the horsepower required increases as the cube of the air speed, the ideal system is that designed with an air velocity sufficient to remove the dust and not in any excess which demands a disproportionate increase in power consumption.

(3) The fan, of the paddle-blade type, for producing the flow of air through the system. These machines should be robustly constructed to withstand much heavier duty than a ventilating fan, especially the impeller.

(4) Equipment for separating the air, used for extracting dust, from the material collected. This may take the form of cyclone collectors, or textile bag filters. Circumstances do, nevertheless, arise where it is necessary to employ a combination of these equipments. Even if it is considered unnecessary to filter the air leaving the cyclone, a point which should not be overlooked is the separation of the fine dust discharged by the cyclone with the waste material. This problem is solved, by providing a fan for connection to the dust hopper, so placing the latter under slight suction, and discharging a comparatively small quantity of dustladen air to a textile filter, where the fine dust is collected in bags. This ancillary system also has the effect of slightly improving the cyclone efficiency.

Pneumatic Hoists

See Hoists : Chain, Pneumatic and Electric.

Portable Conveyors

Portable conveyors, as with all other handling equipment of the same type, are constructed to be wheeled to the point where the movement of materials is required. They are built for the purpose of the transfer of materials from one place to another on ground level; for the stowage of materials one upon the other, or stacking; to load vehicles, either from ground level or from a system of conveyors; and generally carry out duties where a fixed conveying system would be unwarranted or uneconomical.

Powered Conveyors

Powered conveyors commonly used in food processing include *(i)* belt conveyors, made level inclined, declined, or as a combination of these features and with flexible steel, stitched canvas, solid woven, rubber-covered duck, and steel-mat or wire-mesh belt, *(ii)* chain conveyors of the apron or slat type, *(iii)* overhead chain conveyors, and *(iv)* screw conveyors.

Powered Hand Trucks

Both horizontal and a combination of vertical and horizontal

movements may be achieved by different forms of industrial trucks. These offer a flexible means of handling materials for intermittent moves, regardless of the limits of any one building or bay, uniformity of loads and rates, and cross-traffic. There are two main groups of industrial trucking systems, these employing, respectively, (1) hand trucks *(which see)* and (2) powered trucks and accessories.

There are five systems of powered industrial truck handling systems, comprising *(i)* the tractor-trailer, *(ii)* platform-truck, *(iii)* low-lift-truck-stillage, *(iv)* high-lift-truck-stillage, and *(v)* fork-lift-truck-pallet. From the basic types of trucks employed in these systems there have been evolved numerous special types for the handling of commodities of sizes, shapes, and forms that are not adapted to trailers, platforms, stillages, or pallets, or that constitute unit loads in themselves. A more recent development is the diverse types of pedestrian-controlled truck, with which the driver walks instead of riding. Various forms of power are employed, but for food processing establishments, where fire and fume hazards are of major importance, the obvious choice is battery-electric propulsion. In certain applications it offers lower operating costs. Furthermore, it is a highly efficient and flexible form of transmission.

The tractor-trailer system is considered the most efficient for hauling materials because the motive unit is separate from the carriers, permitting pulling instead of carrying and greater utilization of the tractor. The system is flexible in that the tractor-trailer train is not confined to any fixed path but may be routed and systemized to tie up into production schedules. Moreover, as the loads are always on wheels, they may be moved short distances by hand, such as between operations or to train assembly points. In effect, a tractor-trailer train when assembled becomes a conveyor, yet unlike a fixed conveyor it may be broken into its components to spot single trailers where required or divert them off regular routes for pick-up or delivery, and it may quickly be adapted to changes in production.

Summarized, the characteristics of the tractor-trailer system are:

(1) Various types of trailers may be used for handling different loads, *i.e.*, platform trailers for yard service, dump bodies for bulk materials, box bodies for small unit packages, dollies for barrels and objects too heavy for platform trailers, etc.

(2) Usage is for distances over 400 to 500 ft.

(3) Higher capacity handling than any other system.

(4) Motive power is not tied-up while trailers are being loaded or unloaded.

(5) The tractor can keep three sets of trailers in use—one loading, one unloading, and one in transit, if unloading and loading facilities are available at terminal points.

(6) Usefulness in collecting and despatching loads to a number of locations, often on a regular route as a production express service.

The platform-truck system where the handling units employed are essentially burden-carrying trucks, with loading and unloading effected by hand, fork-truck, cranes or other means of elevating the loads. Generalizing, it can be said that for transporting a limited number of loads from point to point over relatively long distances the logical choice would be a non-elevating platform-truck, but where volume and distances are factors, the tractor-trailer system would be the more useful equipment. The main characteristics are:

(1) For heavier loads, longer distances, say up to 400 to 500 ft, more rapid and more continuous service than pedestrian-controlled trucks.

(2) Not self-loading.

(3) Idle during loading and unloading operations.

Low- and high-lift systems: Trucks of the low- and high-lift types are similar in construction except for the elevating features. Low-lift trucks have maximum lifts to approximately 24 in, whereas high-lift trucks have lifts to about 70 in and when equipped with telescopic features can raise loads to 10 ft 10 in or more, and yet collapse for passage through doorways, etc.

Elevation of the platform is accomplished by a hydraulic ram activated by pressure oil or by double chains sprocket-driven from an electric motor through a gear reducer. Speed of hoisting ranges from 10 to 20 ft per min, depending upon the load and capacity of the truck, while travelling speeds average 5 to 6 m.p.h.

Employment of the low-lift or elevating platform stillage or pallet system is dictated for the movement of goods over relatively short distances, as between production operations in the servicing

of work-stations and in inter- and intra-plant movements of materials where a regular tractor-trailer train service is not warranted. The most outstanding characteristic is, of course, the embodiment of self-loading features enabling one truck to service a number of production points without the need for external means for on- or off-loading.

The latter is facilitated by the use of many developments arising from the original platform stillage. These include stillages with ends and sides permanently fixed to the platform, removable boxes of varying depth arranged to be superimposed, fixed shelves and racks and many special arrangements to suit particular commodities.

Fork-truck-pallet systems: Fork trucks differ from lift trucks in having load-carrying forks and a tilting mechanism on the load rack, 10 to 15° backward and 3 to 5° forward to cradle the load and facilitate unloading respectively. The latter may be by double chains sprocket-driven from an electric motor through reducing gear, or hydraulically. In the former case, forward and backward tilting movement of the mast is achieved through the medium of two tooth racks, whilst in the latter case two hydraulic cylinders provide mast angle control. A hydraulic cylinder also gives the desired fork elevation. Both types of trucks may be fitted with single lift or telescoping masts. The latter are necessary when making full use of 'air-tight' in warehouses and stores.

Attachments: Many special types of fork trucks are available for specific purposes, where the volume of work justifies the application. In the main, however, for general usage, these requirements may often be satisfied by standard units of the desired capacity fitted with alternative handling attachments. Thus, whilst some objects not on pallets may be picked up by the standard pallet forks, such loads may be better handled, and in some cases, only handled, when chisel point forks have to be substituted. For handling long or oversize crates, extensions may be added to the conventional forks. Other attachments extending the use of the truck and rendering it more valuable to the user include crane attachments for lifting unit loads; rotating head which turn the load through 180° and thus allow the content of drums, bins, etc., to be poured or emptied; back rests for supporting high loads; squeeze clamps for the easy handling of boxes, bales, drums and loads not requiring pallets; push frames to assist in the

removal of the pallet load from the tines of the fork; clamps designed to draw the load on to the forks; scoops for the handling of bulk material, etc.

Selection: In order to select the industrial-truck system best suited to the job, it is necessary to know (1) distances to be travelled, (2) tons handled per trip, (3) trips per work-shift and (4) the number and height of the tiering operations to be carried out. The tons handled per trip, or size of unit load, will automatically determine the required size or load-carrying capacity of the truck. The number of trucks required to handle the work involves a practical engineering computation. First, however, the best suited type of truck must be determined, and this will be influenced mainly by the distances and tiering.

The ideal handling system is one containing no lost motions and requiring no manual handling. This ideal is most nearly approached in the fork-truck-pallet and the lift-track-stillage systems. These are therefore the ones between which the first choice will normally lie. The former is the most widely applicable of all. In the small plant, therefore, it is likely to be first choice since it may be adapted to most types of handling operations. It is generally best for tiering and vehicles loading because in such work pallets are preferable to stillages. When loads are heavy and tiering is unimportant, the low-lift-truck-stillage system has advantages over the fork-truck-pallet system in that loads are not carried in an outboard position and no counterweight is needed; as a result less dead weight must be moved for a given load. It is not so well adapted to vehicle loading because stillages require too much under-clearance for the lowest-cost packaging.

Where the volume of work warrants, both systems can be used, the fork-truck-pallet system for tiering and vehicle loading, and the low-lift-truck-stillage system for other hauls. Where distances are a factor the tractor-trailer system has advantages. Loads may be narrower and more of them hauled in one trip. Cost per ton-foot is less. As already explained, the tractor-trailer system must be provided with an external means of loading and unloading. If these operations have to be performed by hand, the cost might easily outweigh the saving in haulage costs. However, the fork-truck pallet system can be integrated with it by the simple expedient of using the fork-truck for setting pallet or stillage loads on the trailers. A truck would also be necessary for unloading at destination

if manual rehandling of individual pieces is to be avoided.

The tractor-trailer system is also practical for movement of materials from operation to operation in process. Trailer loads cannot be coupled as quickly as stillage loads and pallet loads can be picked up, but trailers can be built to handle very heavy loads. Therefore, if loads are heavier than can be practically handled on stillages or pallets and the production operation is such that the pieces of materials can conveniently be picked up from one trailer and piled on another, the system may be found useful.

Various physical conditions within a factory must be considered at the time of installing an industrial-truck handling system. These generally are: *(i)* Type and condition of floor; *(ii)* maximum height and width of doors on transportation routes; and *(iii)* minimum width of intersection right-angle aisles. Floors should be hard, smooth, and level. For industrial trucks equipped with solid tyres a smooth surface of cement, asphalt, wood blocks or brick results in a tractive resistance of approximately 40 lb/ton weight of truck and load, but the same floors, if not properly maintained and allowed to become rough and uneven, may offer a tractive resistance of 50 lb/ton and sometimes more. Inclines or gradients will offer increased resistance to tractive efforts and this is assessed at approximately 20 lb/ton for each foot of vertical rise per 100 ft travelled. Thus, when gradients are unavoidable, they should be kept as easy as possible.

All doors and aisles should be large enough for easy passage of the largest truck and load. Good practice indicates making aisles in working areas large enough for two trucks to pass each other easily. In storage work, where every inch of space should be usefully employed, one-way traffic is essential for all aisles used as roadways only. In this case the minimum permissible width of equal intersecting aisles is required. This information may be secured from makers' literature. Allowances may, however, have to be made for the anticipated width or length of the loads carried by low-lift or fork-trucks.

Control systems: It is not possible to lay down any hard and fast rules about what systems of control should be used to operate a trucking system; the methods of control will be governed largely by the layout of the plant and the nature of its products. Where power-operated trucks are used to any marked extent the methods usually employed are as follows:

(1) The assignment of a given number of trucks to manufacturing or other departments, each department being responsible for the movement of materials onwards.

(2) The despatch of trucks from a central control when called for by departmental managers.

(3) Centralized control, with trucks making scheduled trips at regular intervals on specified routes, including factory services.

System (3) often offers the most advantages in that it is possible to obtain the shortest and most direct line of travel between any two departments, the control department can plan schedules from day to day to meet the demands of production, and by reason of a more systematic operation a high utilization of handling equipment and handling labour is secured. It can also be seen that trucks operated from a central control are used to their maximum capacity, in that the truck despatcher can plan their movement whether they are needed for the continuous movement of materials on scheduled routes at regular intervals, or for the movement of loads for which service has been requisitioned.

Pusher-Bar Conveyors

See Chain Conveyors.

'Redler' Conveyor

The principle of the flight conveyor forms a basis for the design of the 'Redler' en masse conveying system. Totally enclosed and dust-tight, these equipments are extensively used for the bulk handling of such materials as sugar, cocoa, tea, coffee, cornflakes, flour, malt milk powders, nuts, grain, salt and starch. Unlike ordinary flight conveyors, which push the materials along the conveyor trunking, the system used skeletonized flights submerged in the material and which induce the product to flow along the conveyor almost as a solid core due to the coherence of the mass. A special advantage is that the conveyors themselves are exceptionally compact and can convey loads within trunking of minimum overall dimensions. The mass movement continues even when the path of the conveyor leads vertically upwards, though spaced clean-out flights are then provided to clear the elevator when the feed has stopped.

Refrigerants

The most common method of refrigeration uses the vaporization of a liquid as a means of producing cold, the heat of vaporization being obtained directly or indirectly from the space or produce being cooled or frozen. In order to be of value as a refrigerant, the liquid must have a high latent heat of vaporization and must evaporate at a comparatively low temperature and pressure. The latent heat determines the weight of refrigerant to be circulated for a given refrigerating effect, whilst the vaporization temperature determines the lowest temperature level which the refrigerating system may produce. Pressure is important in that it governs mechanical strength of a refrigeration plant. High pressures, especially in the condenser, add greatly to the expense of construction, as extra-heavy pipes, fittings, stuffing-boxes, etc., are needed. Leaks are more difficult to prevent as pressures increase.

The volume of vapour per lb at the temperature and pressure at which the refrigerant is used is also important, as it controls the size of the refrigerating machine and of the containing vessels. For example, to maintain an evaporating temperature of –17.8°C (0°F) with ammonia requires a pressure of 30.41 psia, at which temperature and pressure of the vapour occupies a volume of 9.12 cu ft/lb. With Freon 12 the pressure required in 23.87 psia and the volume of the vapour is 1.637 cu ft/lb, whilst in the case of carbon dioxide the pressure and volume are 303 psia and 0.282 cu ft/lb respectively. However, although ammonia occupies more space than the other two refrigerants, its latent heat is greater and its operating characteristics are very satisfactory from the viewpoint of power consumption per ton of refrigeration over the wide range of temperatures called for in commercial refrigerating practice. Other factors to be considered in application are toxidity; corrosive action on metals, fire and explosion hazard.

Refrigerants commonly used are ammonia and Freon for land-based installations, carbon dioxide for ship-board installations, and Freon, Dielene, Carrene and sometimes water vapour in air-conditioning work, as follows:

Ammonia (NH_3): Anhydrous ammonia is the most widely used refrigerant for commercial work. It has medium pressures and the number of cu ft of piston displacement per unit of refrigeration is nominal. This makes it possible to produce a given amount of

refrigeration with a small compressor. Ammonia vapour is, however, dangerous to animal life and is a strong irritant, besides being explosive when mixed with air in volumes of 13 to 27 per cent. Both the liquid and vapour react chemically on non-ferrous metals and their alloys if containing traces of water vapour, and as such, pieces of plant in contact with the refrigerant should be constructed entirely in ferrous metals. Anhydrous ammonia has little or no effect on petroleum oil, but in the presence of moisture, at the usual temperature in compressor, it has a tendency to make an oil emulsion.

Care should be exercised to ensure that ammonia leaks do not occur at pipe connections; the vapour is very light and readily finds its way through joints. Leaks are easily detected by smell, but their location is more difficult. This can be done by means of a lighted sulphur stick or candle, which when moved at a distance of about 1 in along all pipes, around all fittings, joints, valves, etc. will show the source of leakage by emitting grey smoke. A burning sulphur candle held in front of the nose will, in fact, permit approach to an ammonia leak without much danger, or even escape from a gas-filled space without serious injury. As water at 10°C (50°F) will absorb about 900 times its volume of the gas, maximum safety is afforded by having a water hose always in readiness for use in case of leaks occurring.

Freon group of refrigerants: These refrigerants are safe from the standpoint of toxicity, since it is necessary to have a comparatively high concentration of the gases before serious poisoning can occur. The Freons in contact with water do not appear to corrode metals any more than water would without the Freons. They are all miscible in the mineral oils used for compressor lubrication; consequently there is no separation or oil blanket formed in the evaporating coils. An oil fog is formed and this at all times returns the lubricant to the oil separator. Observed effects of oil miscibility are raising the evaporating temperature from .9 to 1.1°C (1 to 2°F) with 10 per cent by weight of oil present and reducing the density of the condensate.

Since the development of Freon in about 1928, there has been a continued increase in usage as a refrigerant in many types of installations. The most commonly used are:

Freon 11 (CCl_3F) *Trichloromonofluoromethane (F-12)*: The liquid has a boiling point of 23.7°C (74.7°F) and a freezing point of

–111.1°C (–168°F). Its critical temperature is 196°C (384.8°F) and its critical pressure is 635 psi. Usage is with centrifugal compressors in air conditioning installations.

Freon 12 (CCl_2F_2) *Dechlorodifluoromethane (F-12)*: This refrigerant approaches nearly to the ideal, and with thermodynamic properties somewhat like those of ammonia, but much safer for general use, lends itself to the reciprocating form of compressor. It appears to be non-irritating, non-inflammable, non-explosive and non-toxic. The liquid has a boiling point at atmospheric pressure of –29.8°C (–21.7°F) at 29.92 in Hg and a freezing point of –190.4°C (–311°F). The critical temperature of F-12, or the maximum temperature at which it can be liquefied, is 111.5°C (232.7°F), and the critical pressure is 582 psi.

Like ammonia, it has a low boiling point, but it is much heavier. One cu ft of F-12 at atmospheric pressure weighs slightly more than 92 1/2 lb while a cu ft of liquid ammonia weighs only 40 lb. A very small quantity of F-12 may be detected by means of a Halide lamp. This boils alcohol to heat a copper wire which burns with a blue-green colour when in contact with a volatile substance containing chlorine. As F-12 tends to remain around a leak or drop downwards and does not diffuse rapidly, leaks may be easily detected by use of the lamp.

Freon 22 ($CHClF_8$) *Monochlorodifluoromethane (F-22)*: F-11 is suitable for use at temperature above –1.1°C (30°F) and working pressures up to 20 psi, whilst its low density makes large volumes necessary; as in centrifugal compression. F-12 covers the operative temperature range or 15.6 to –62.2°C (60 to –80°F) at pressures up to 150 psi. On the other hand, F-22 is suitable for a temperature range of 10 to –73.4°C (50 to –100°F). Working pressures are up to 250 psi, calling for slightly stronger construction than required by F-12. It gives about 65 per cent more refrigeration for a given volume than F-12 and is particularly valuable for low temperature work.

Carbon dioxide (CO_2): This refrigerant, like anhydrous ammonia, is used for a temperature range 15.6 to –51.1°C (60 to –60°F). The gas is free from smell, fire or explosion risk and mixed with air it is perfectly safe in nominal amounts unless the exposure is too prolonged or the amount of oxygen is low. Carbon dioxide is used in much the same manner as ammonia, but the pressures required are much higher, *i.e.*, up to 1,000 psi. Hence, stronger construction

is needed. A low critical temperature, *i.e.*, the temperature above which it cannot be liquefied, limits applications to locations where the condensing water temperature does not rise to a point near or above 31.4°C (88.4°F). Where these are unduly high, as under tropical conditions, resort is had to dual compression. Leaks, where they occur, are unusually heavy, but can be easily detected by the application of a soap solution to all joints.

Because of the large weight per unit volume of carbon dioxide, its refrigerating effect for a given volume is also high. A compressor using carbon dioxide requires only about one-fifth as much cylinder displacement as a machine using ammonia for the same amount of refrigerating effect. When making such comparisons it is to be observed that because of the low heat content of F-12, the weight of refrigerant circulated per minute per ton of refrigeration is much higher than for other common refrigerants and is but a little higher than carbon dioxide. However, as the specific volume is much lower than for the former, but higher than carbon dioxide, the theoretical piston displacement for F-12 is about 1.69 times as great as for ammonia.

Dielene ($C_2H_2Cl_2$) *and Carrene* (CH_2Cl_2): These are the commercial names given, respectively, to the refrigerants dichlorethylene and dichlormethene, the pure form of methylene chloride. Both are used in airconditioning work. Dielene as a boiling point of 50.1°C (122.4°F) and a freezing point of –56.7°C (–70°F). Its critical temperature is 232.2°C (450°F), corresponding to a critical pressure of 795 psi.

Carrene has a boiling point of 40.3°C (104.6°F), a freezing point of –96.8°C (–142°F), a critical temperature of 216.1°C (421°F), and a critical pressure 670 psi. The refrigerant is liquid at all normal atmospheric temperatures. It has a faint odour which is not unpleasant, is non-corrosive, non-inflammable and does not form explosive mixtures with air. Furthermore it does not support combustion and is an excellent fire extinguisher. Another characteristic of Carrene making it an ideal refrigerant are low-working pressures, which enables a system using Carrene to be opened up at any connection without danger of fire or explosion. No pressures in the system exceed atmospheric temperature unless the temperature of the external environment is 37.8°C (100°F) or more.

Refrigerated Road Transport

Speed of movement coupled with refrigeration has provided the means for obviating any depreciation in quality of chilled or frozen produce during shipment, the speed being secured not so much by high rates of travel as by door-to-door service. These facilities are offered mainly by refrigerated road transport, comprising insulated bodies based on commercial vehicle chassis or lift-off insulated containers carried on flat platform type vehicles, each fitted with means for maintaining the required temperature conditions within the insulated space.

The design of these refrigerated road units depends not only on the type of goods they have to carry, and for which the temperature requirement may vary considerably, but also in the nature of their task, *i.e.*, whether for transport in bulk to one point of delivery only, or for delivery to a number of retail shops during one journey. The bulk of refrigerated vehicles fall into two main groups, *i.e.*, those used for trunk work, and those for delivery to a large number of points. Bodies and construction for both types of service are of specialized construction, combining operational durability, lightness of weight and good thermal insulation. Lightness of weight is synonymous with maximum payload, but additionally, consideration is given to the space occupancy of the insulating materials. Expanded plastics are widely used.

A number of methods are employed to secure the desired refrigerating effect within the insulated space, these including:

(1) An engine, vehicle or motor driven refrigeration unit, with or without means for operating the unit from an external power supply when the vehicle is stationary.

(2) Hold-over (eutectic) plates serviced by a motor-driven refrigeration compressor, which takes its power supply directly from the electric main whenever the vehicle is stationary.

(3) Evaporation of liquid nitrogen sprayed into the insulated space.

(4) Controlled evaporation of solid carbon dioxide stored in ice-bunkers.

Any of these machines caters for a wide range of operating temperatures, but the distribution of temperatures throughout the bulk of the produce carried will not be equable unless attention

is accorded to careful stowage. This is specially true when air circulation by natural convection is used. Provision must be made to permit free passage of cooling air throughout the stack. With forced air circulation, the resistance offered to air flow will have less effect, but forced air circulation will be found ineffectual if the pack is too solid.

Roller Conveyors

An outstanding feature of this type of equipment is that it can be either a fixture, or erected as a temporary expedient to effect handling at any point,, thereby providing great flexibility. The conveyor is usually mounted on adjustable trestles of sufficient number to carry the load and to effect stability, and gravitational movement is obtained by varying the gradient at which the conveyor is set from 1 1/2 to 7° to suit the weight and character of the materials in contact with the rollers. These conveyors are constructed of a series of rollers provided with ball-bearings, mounted in a single row between two frame rails or in a double row in three frames. The usual construction is the two-rail type, but for conveyor widths over 28 in the three-rail type provides better operation and an increased bearing capacity to the length of the load. Furthermore, if the rollers are tilted or 'cut' slightly towards the centre, the three-rail conveyor is self-centring and the load stays on the track without guard rails.

Standard 45-, 60-, and 90-degree curves are used for change in direction. These curved sections are of three types, straight, multi-rail straight, and tapered roller. With straight roller curves the surface speed is constant for the full length of the roller and tends to move the load straight ahead, rather than around the curve and then twisting it on the conveyor. Turning of the load can be partly overcome by changing the roller lead by placing the outer end of each roller ahead of its true radial position. The multi-rail straight roller curve, also called a differential curve, reduces twisting of the load and permits closer spacing of the rollers. The tapered roller curve eliminates entirely any twisting of the load as the rollers are tapered to the centre of the curve, thus giving a varying surface speed across each roller.

In layout of a roller conveyor system it is often necessary to transfer loads from one line to another. The lines can converge or they may be at right-angles. Conveying lines may be connected

by spur or live rollers, or by switches. Spur sections are of several types, including plain, frog, and spur junctions at different angles. Converging sections include straight frog, 90° frog, and straight connecting sections. An arrangement of automatic stops can be provided to prevent possible interference of items at the converging point. Switch sections can be arranged to connect a single line to two or three lines. The two-way and three-way switches, as they are kown, have a centre or tongue section pivoted at the end connected to the single line and free at the other end to swing laterally on a switch plate. Movement is made either at the section or from a distance by means of a cable, lever arm or an electric motor. Limit stops prevent the switch section from running off its track on the switch plate.

The ordinary pivoted switch cannot serve more than three lines and is not too practical for small pieces because of the unavoidable gap that occurs at the pivoted end and the difficulty of securing proper guard rail connections for the change in direction of travel. To avoid these problems a flexible switch, known as a radial or alligator switch, can be used. The receiving end of the swinging section is made up of rollers separately mounted so that they remain radial at all times and in proper alignment with each other. Each radial may carry its own guard rail. Radial switches are readily adapted to automatic operation and control by photo-electric cells.

For transferring loads between parallel conveyor lines, transfer cars can be located on track running along one end of the lines. Rolls on top of the car receive the load, the car is moved opposite the desired line and the load discharged for either further movement or storage. Movement of a load between conveyors running at right-angle to each other can be effected by rotary transfer tables or by ball tables. The latter are more readily adapted to production conveyor lines and can be used as work or inspection tables and often with scales as weighing platforms.

Selection

Determination of the proper type of roller conveyors to be applied to a handling project requires the compilation of certain basic data. In practice many roller conveyor lines are called upon to effect duties well in excess of that for which they were designed. This results in accelerated breakdown rates. The data to be

ascertained is:

(1) Maximum and minimum dimensions of the commodities to be conveyed.

(2) Maximum and minimum weights of the commodities to be conveyed.

(3) Full particulars of the actual riding surface of the commodities. This applies when the commodity has not a riding surface the full width.

(4) Kind of material out of which the container is made, or of the commodity, if it is intended to convey it without a container.

For such commodities which have a hard, smooth riding surface, such as wood cases, the length of the roller may be equal to the width of the maximum commodity, and in some cases even less providing the overhang is not a detriment. When cartons are to be conveyed, it is the usual practice to have the rollers 2 in longer than the maximum width of carton. In cases where it is essential to keep the full riding surface on the rollers all the time, the rollers are made at least 3 in longer than the maximum width of the riding surface, so that the ends of the rollers will be in the correct relationship with the guard rail clearance, which is 3 in more than the maximum width of the commodity conveyed.

To convey objects having a smooth, hard surface, at least two rollers are required under the object at all times. In handling some kinds of equipment when vibration is serious, three or more rollers are required under the object. The greater the number of rollers the smoother is the operation. If the load of the commodity is such that the load per roller is greater than the rated capacity, then it will be necessary to space the rollers closer, or else use a heavier type of roller. Care should always be taken that the total rated capacity of the number of roller supporting the commodity is never exceeded by the total weight of the commodity.

Roller Flight Conveyors

See CHAIN CONVEYORS.

Scraped-Surface Heat-Exchangers

Plant of this type is employed for the continuous cooling or freezing of a wide variety of materials. It consists basically of a

cylinder constructed by two concentric tubes, the outer tube forming a jacket through which the refrigerating medium (such as brine, ammonia or Freon) is circulated and the inner tube housing a rapidly revolving mutator shaft fitted with two rows of scraper blades. Material to be processed is pumped through the narrow, annular space between the inner, or heat-transfer, tube and the mutator shaft, and during its passage is agitated by the scraper blades, which also keep the heat transfer surface clean. This dual action effects a high rate of heat transfer with viscous and liquid products; as for example, in slush freezing, freeze concentration and ice-cream processing.

It should be noted that the slush freezing process has been developed to produce a frozen slush of various fruit juices, with the objective of removing as much heat as possible from the produce to reduce the refrigeration load of the hardening or freezing room. Economy is not the primary objective of freeze concentration. It is that of processing heat sensitive materials containing delicate flavours, which, for the retention of flavour, demand minimal handling time. The process is based on the principle that when an aqueous solution is partially frozen pure ice separates out and the solutes in the liquid phase are concentrated. The ice can be removed by basket centrifuge.

Use in ice-cream production is to give the mix a preliminary freezing following pasteurization and prior to hardening. Requirements are the addition of air during freezing, vigorous mixing during the entire chilling cycle and short freezing time to give a fine crystal structure in the product. Freezing to a draw temperature of –8.9 to –7.8°C (16 to 18°F), together with the continous scraping of ice-cream from the heat-transfer surface ensuring good heat transmission, results in the formation of approximately 70 per cent ice crystals based on total moisture content of the mix.

At the same time, air to the necessary hygienic standard is added to the mix, causing it to foam so that its volume is increased up to double that of the pure liquid; 'overrun' may thus reach up to 100 per cent. Vigorous, intensive mixing of ice-cream and air by the mutator shaft and blades throughout the whole continuous chilling cycle also tend to produce finer crystals of more uniform size than those formed in conventional freezer.

Scraper Flight Conveyors

See CHAIN CONVEYORS.

Screw Conveyors and Elevators

Screw or worm conveyors provide dust-tight fully protected transport for many classes of food products in bulk. They comprise a continuous or broken-bladed screw fitted to a rotating spindle, the whole of which revolves in a suitable trough. The screwing action as the worm or screw turns propels the material being conveyed from one end of the trough to the other. Various forms of screw are employed, these being crescent-bladed, paddle-worm, continuous spiral and open spiral. The first two of these, the crescent-blanded and the paddle-worm, are useful in so much as it is possible to reverse the movement of the material in the conveyors by reversing the pitch of the blades. Delivery at any point in the conveyor can be arranged by fitting suitable open chutes along the length of the conveyor. The worm elevator is constructed on similar principles to the worm conveyor, being used for light duties. The combination of worm conveyor and elevator provides for both horizontal and vertical movement of materials.

Slat Conveyors

See CHAIN CONVEYORS.

Solid Adsorbents

See AIR CONDITIONING.

Solid Carbon Dioxide

The properties of solid carbon dioxide, also termed dry ice, are as follows:

Melting-point	–78.5°C (–109.3°F)
Latent heat of sublimation	246.4 Btu/lb
Total heat to 32°F	285 Btu/lb
Specific gravity ice	1.57
Specific gravity snow	1.3 to 1.5

One cu ft dry ice at 1.3 spec. grav. will absorb 22,300 Btu on sublimation. One cu ft water ice will absorb 7,970 Btu on melting at 0°C (32°F).

Unlike water ice, dry ice sublimes on taking up heat, *i.e.*, passes from a solid to a gas without liquefying. The heavy gas evaporated from the block fills any container with carbon dioxide and excludes air; this has marked preserving properties and, since it will not support life, inhibits the growth of living organisms. The gas film surrounding a block of dry ice and the frost crystals, which form on its surface, have good heat-insulating properties, so that the wastage is lower than might be expected, so much so that solid carbon dioxide cannot readily be made to take up heat unless steps are taken to provide heat-transmission surfaces.

It may be used for cooling in transit many frozen products, notably ice-cream and quick frozen packeted foodstuffs, all of which may be packed in non-returnable cartons or light-insulated containers; for cooling refrigeration vans and for a wide range of commercial and industrial processes. Care is required in its application to the carriage and storage of chilled goods held at temperatures above freezing. Although safe and clean it will 'burn' the skin and produce frost-bite if carelessly handled, and adequate ventilation should be provided to disperse large accumulation of the evaporated gas when stored in bulk.

Spiral Conveyors and Chutes

Gravity movement of materials may also be effected by spiral (helical) conveyors. These are of two types: roller spiral conveyors and spiral chutes. Both serve the same purpose of lowering articles from one floor to another, or from a higher level to a lower, and can be made to serve any number of floors. Loading and unloading stations can be arranged on any or all floors according to requirements.

Roller spiral conveyors consist of a number of curved sections of roller conveyor set in the form of a spiral with considerable slope varying from 5 to 10° and mounted in a structural steel frame. They offer several advantages over other methods of lowering articles in *(i)* requiring no power, *(ii)* permitting slow and easy descent, *(iii)* allowing for considerable storage, *(iv)* conveying open containers or trays without spilling the contents, drums and barrels in an upright position and fragile articles without damage. Of the three standard types, straight, multiple and tapered roller, the last give the best results as it provides better bearing to the load and reduces friction between load and outer guard rail.

Straight and spiral chutes, while limited in application because of the steep pitch required to overcome friction, are useful for lowering items from a higher to a lower level. Loading and unloading stations can be provided at any desired intermediate position along the spiral. The receiveing and discharging chutes are made as tangential continuations of the spiral chute. On the discharging chute, a hinged deflector is arranged to divert articles from the spiral chute. It is never good practice to use a chute for storage.

Articles that do not require especially careful handling, such as boxes, crates, bundles and cases, can be handled efficiently by spiral chutes, but when careful handling is necessary, roller spirals are best. The nature and size of the item to be conveyed governs selection of a chute and its dimensions and pitch. For general conveying between floors, the pitch may vary from 20 to 30°.

Steam Jet System

The steam jet or vacuum refrigeration system is used principally for air conditioning or refrigeration at temperatures above 0°C (32°F). The system functions on the principle that water under high vacuum will vaporize at low temperatures, and steam ejectors of the type commonly used in power plants for various processes will produce the necessary low absolute pressure to cause evaporation of the water. The water to be cooled enters the evaporator and is cooled to a temperature corresponding to the vacuum maintained. Because of the high vacuum, a small amount of the water introduced in the evaporator is flashed into steam, and as this requires heat and the only source of heat is the rest of the water in the evaporator tank, this other water is almost instantly cooled to a temperature corresponding to the boiling point, determined by the vacuum maintained. The amount of water flashed into steam is a small percentage of the total water circulated through the evaporator, amounting to approximately 11 lb per hr per ton of refrigeration developed. The remainder of the water at the desired low temperature is pumped out of the evaporator and used at the point where it is required.

The ejector compresses the vapour which has been flashed in the evaporator, plus any entrained air taken out of the water circulated, to somewhat higher absolute pressure, and the vapour and air mix with the impelling steam on the discharge side of the

jet. The total mixture of entrained air, evaporated water and impelling steam is discharged into a surface condenser at a pressure which permits the available condensing medium to condense it. The resulting condensate is removed from the condenser by a small pump, from which it can be discharged to the sewer or returned to the system in the form of make-up water, or part of it may be returned to the boiler feed pump. The slight amount of air which may be entrained in the cooled water is removed by a small secondary ejector which raises the pressure sufficiently so that the air can be discharged to the atmosphere. A small secondary condenser is necessary to condense the steam used in the secondary jet.

Steel Band Conveyors

The conveying bands fitted to these handling equipments are manufactured on either hardened and tempered carbon steel or hard-rolled stainless steel. The latter is intended for those installations where a high degree of anti-corrosiveness and freedom from unhygienic conditions is demanded; they are thus particularly suited to the food industry. The mechanical construction of the steel band conveyor is similar to that of any other belt conveyor, except that larger terminal pulleys are necessary to reduce the stresses in the band that would occur if small pulleys were used, and on account of its mechanical strength, less idlers are necessary. Furthermore, due to its stiffness, hardness and good elastic qualities, only a low motive power is required for driving the conveyor.

In addition to having a smooth, non-porous surface which is easy to keep clean, steel bands can be advantageously employed in warm localities, drying chambers, and in ovens. The conveyed material can be discharged from the band at any point by the use of ploughs or oblique deflectors. They may also be adapted to form conveyor tables, on which the materials are subject to some kind of treatment during transportation, as for example, the cutting of meat, sorting and cutting of vegetables, filling of cans and bottles, etc. Such conveyor arrangements are usually called working-tables, because the working places are located adjacent to the conveyor band. Another outstanding arrangement permits a movement of materials whilst some physical process, chemical reaction or heat-exchange takes place in it; a handling feature that offers considerable advantages in that speed of travel may be

accurately controlled to conform exactly to process requirements. An example here would be cooling, heating, solidification or crystallization processes.

Such a plant would incorporate a steel band, the top strand of which continuously passes over a trough of circulating water. In operation the water pressure is just sufficient to raise the band off its supports, and the surplus water overflows into gutters which collect and return the water for recirculation. In this way, the whole of the band is therefore in contact with the coolant, and to increase the cooling further, the band runs through an air-conditioned chamber, through which a fan pulls a continuous draught of clean, cool, air. Where the problem calls for the application of heat, as in the evaporation of moisture, heat is applied to the underside of the steel band; furthermore, the width of the band, speed of operation, temperature of the heating or cooling medium, etc., all depend, of course, on the requirements of the individual application.

Superheating

The term superheating is applied to the rise in temperature which occurs when the cold suction gas is drawn into the cylinder and absorbs some of the heat from the piston, cylinder walls, etc., caused by the previous compression stroke. As the volume of a given weight of gas increases with temperature, the heating of the gas results in less weight of gas being drawn into the compressor cylinder and consequently reduces the amount of effectual work done per stroke. In order to reduce this loss to as small proportions as possible the wet compression method has been largely adopted.

Surface Cooling Coils

See AIR CONDITIONING.

Suspended-Flight Conveyors

See CHAIN CONVEYORS.

Swing-Tray Elevators

See ELEVATORS.

Thermometers

As the whole art of refrigeration is merely that of the control

of temperatures, the provision of instruments to indicate how effectively that control is being carried out is naturally important. Thermometers for refrigerating service have been specially developed by the makers to fulfil the special requirements of their duties, and they can be divided into two broad sections, the mercury- or spirit-type direct reading thermometer, and the distant reading type which may work on the electrical resistance, mercury-steel, or vapour pressure systems. Recording charts can also be fitted to the latter types so that an indisputable record of the temperature variation in a chamber can be obtained.

The mercury in steel thermometer is similar to the ordinary glass thermometer in principle, the mercury being contained in a steel bulb connected to a pressure gauge by fine capillary tubing. Excellent instruments of this type can be obtained with lengths of tubing up to 50 ft.

Electrical thermometers work on the principle that the resistance offered by a metal to the passage of an electric current varies with its temperature. The thermometer head or resistance head is placed in the cold room or chamber and connected by means of a 'Wheatstone Bridge'-type circuit to a moving coil galvanometer calibrated to give direct temperature readings. It is possible to have the galvanometer installed in a central position, and, by means of a selector switch-board, the temperatures ruling in half a dozen separate chambers can be ascertained rapidly. Recording devices may be used with these instruments and a 24-hr record made on one chart. Some multi-point temperature recorders have a rotating printer which with coloured inking pads stamp coloured dots and numbers on a continuous chart.

Of the glass-type thermometer little need be said. Special attention has been given to their design by the makers; the scales are accurately engraved so that correct readings can be obtained. In the 'Hezzanith' type devices are introduced to prevent frosting of the scales, and cushioning pads to reduce the likelihood of damage through vibration or shock are fitted. Interchangeable scales and tubes are also provided, so that replacements can be effected without removing the thermometer body from its position.

Two-Line Conveyors

See CHAIN CONVEYORS.

Tractors

See POWERED TRUCKS.

Transfer of Fluids

Transfer of fluids may, and often is, effected gravitationally, but for many purposes the most positive way of transferring fluids from one location to another is by pumps and piping. Conveyance is effected through the piping, while by increasing the pressure of the fluid, pumps supply the driving force necessary for flow; overcoming frictional resistances, changes in elevation, changes in internal energy and other resistances set up in the flow system.

The pump and piping must be considered as an integral transfer system. This interrelationship is typified in the choice of materials, while any departure from optimum sizes in any given piping system is soon reflected in increased costs for pumping power. For maximum efficiency in the transfer of fluid, the piping system must be properly designed and installed.

Pumps

Pumps may be divided into four main groups: reciprocating or positive-displacement pumps; rotary centrifugal pumps; rotary positive-displacement pumps, and air-displacement systems. The selection of which type to use is governed by many different factors. The type of flow distribution, or service to be performed, will have an important influence. A pump required for continuous service will naturally be subjected to different treatment than a pump required for intermittent or standby service. In addition, conditions under which the pump must operate and any restrictions on the size or location of the pump must be taken into account.

The density and viscosity of the fluid influence the power requirements and corrosive properties of the fluid determine the acceptable materials of construction. If solid particles are suspended in the fluid, or the fluid is highly viscous, certain types of pumps may also be eliminated. The amount of fluid that must be pumped determines the size of pumps. The head change across the pump, or the increase in pressure of the fluid due to the work input of the pump, is influenced by the inlet and downstream reservoir pressures, the change in vertical height of the delivery line, and frictional effects, and is a major item in determining power requirements.

Most of the pump types embraced in the four main groups are applied to the handling of fluidized foods, but centrifugal pumps and rotary-displacement pumps are the most common. Both operate with no valve action, and in each case application developments have rendered them suitable for handling a wide range of fluids. However, irrespective of the pump type used it is essential that the materials of construction have no action on the substance handled and that the interior of the pump is at all times ready of access for cleaning purposes.

Process Pipelines

Considerable attention should be paid during the design of a pipeline layout for the conveyance of fluidized foods to ensure that resistance to flow is kept to a practical minimum and, in consequence, the amount of power required for the particular operation. When a fluid flows through a pipe, the energy loss through friction is determined by the properties of the flowing fluid and the extent of the piping system. Thus, for steady flow through long, straight pipes of uniform diameter, the variable affecting frictional losses are not only the velocity, density, and viscosity of the fluid, but also the diameter, length and surface roughness of the pipes. Additionally, attention must be directed to the avoidance of sudden change in cross-sectional area of piping, otherwise an appreciable amount of mechanical energy will be lost as friction. Similarly, bends, fittings, valves, orifices, and other installations that disturb the flow pattern can, if not carefully selected, cause undue frictional losses.

The special requirements of food processing also demand that the piping is hygienic, contamination free, resistant to abrasion and corrosion, free of obstructions likely to cause lodgement of food particles, and can be easily cleaned. This restricts choice to a few materials, such as stainless steel, glass, and plastic materials. Other considerations are the effects of temperature level and temperature change; flexibility of systems to thermal and physical shocks; adequate supports and anchorage; ease of installation, maintenance, and in spection; safety in use; possibility of future changes in the piping system.

Trucks

See Powered and Hand Trucks.

Table 3
Cold Storage Data for Perishable Foodstuffs

Chilled Fruit

Fruit	*Temp.* °C	*Temp.* °F	*R.H. per cent*	*Expected storage life*
1	*2*	*3*	*4*	*5*
Apples (depends on variety)	-1-4	30-39	85-90	3-6 m
Apricot	-1-0	30-32	90	2-4 w
Avocado	5-10	41-50	90	2-4 w
Banana:				
Green	11.5-14.5	53-58	90	10-20 d
Coloured	14-16	57-60	90	5-10 d
Bilberry	-1-0	30-32	85-90	2-3 w
Blackberry	-1-0	30-32	90	5-7 d
Blackcurrent	-1-0	30-32	90	1-2w
Cherry	-1-0	30-32	85-90	1-4 w
Coconut	0	32	80-85	1-2 m
Cranberry	2-4.5	36-40	90	1-3 m
Date (cured)	-2-0	28-32	70	4-8 m upto 1 yr
Fig (fresh)	-1-0	30-32	90	7-14 d
Gooseberry	0	32	90	2-3 w
Grape :				
Short storage (type Concord)	-1-0	30-32	85-90	3-4 w
Mean storage (type Chasselas), Muscat, Sultanine	-1-0	30-32	85-90	2 m
Long storage (type Empereur Barlinka, Servant, Ohanez)	-1-0	30-32	85-90	3-6 m
Grapefruit	10-15	50-59	85-90	3-12 w
Guava	7-10	45-50	90	3 w about
Kaki (Persimmon)	-.5-0	31-32	85-90	3 w about
Lemon (green)	11-15	20-59	85-90	1-4 m
Lime	9-10	48-50	85-90	3 w
Litchi	0	32	90	5-6 w
Loganberry	0	32	90	7 d about
Mango	10	50	90	2-5 w
Melon	4-10	39-50	85-90	1-4 w
Honeydew	over 19	over 60	—	—
Nectarine	-1-0	30-32	85-90	3-7 w
Nuts: Brazil, Pecan, Chestnuts	0	32	70	8-12 m
Nuts, other	7	45	70	1 y about
Orange	2-7	35-45	85-90	1-4 m
Pawpaw (papaya)		50	90	2-3 w
Peach		30-44	85-90	1-4 m

(Contd.)

1	2	3	4	5
Pears (depends on variety)	-1.5-1	29-34	85-90	1-6 m
Pineapples :				
Green	10	50	90	2-4 w
Ripe	7	45	90	2-4 w
Plums	-.5-1	31-34	85-90	2-8 w
Pomegranate	1-2	34-36	90	2-4 m
Quince	0	32	90	2-3 m
Raspberry*	0	32	85-90	3-5 d
Red current	0	32	90	2-3 w
Rhubarb	0	32	90	2-3 w
Strawberry*	0	32	85-90	1-5 d
Tomato, ripe (coloured, firm)	0	32	85-90	1-3 w
Tomato, green	11.5-14.8	53-57	85-90	3-5 w

* Higher storage temperature may be advisable to avoid condensation of removal.

Frozen Animal Products

(a) Meat and by-products				
Beef	-12	10	95-100	5-8 m
	-15	5	95-100	6-9 m
	-18	0	95-100	8-12 m
	-24	-11	95-100	18 m
Ground meat, packaged	-12	10	95-100	5-8 m
(unsalted)	-18	0	95-100	8-12 m
Lamb	-12	10	95-100	3-6 m
	-18	0	95-100	6-10 m (up to 12)
Pork	-21	-6	95-100	15-18 m
	-12	10	95-100	2-3 m (up to 5)
	-18	0	95-100	4-6 m
	-23	-10	95-100	8-12 m
Becon, fresh (green)	-23 to -18	-10-0	95-100	4-6 m
Offals, edible (packaged)	-18	0	95-100	3-4 m
Lard	-18	0	95-100	9-12 m
(b) Poultry	-12	10	Moisture-	3 m
	-18	0	vapour-proof wrapping essential	6-8 m
(c) Rabbits	-23 to -18	-10-0	95-100	Up to 6 m
(d) Whole eggs, liquid	-15	5	In sealed contain-ers	6-10 m
	18	0	—	8-15 m

Chilled Animal Products

Product	Temp. °C	Temp. °F	R.H. per cent	Expected storage life
(a) Meat and by-products				
Beef	-1.5-0	29-32	90	4-5 w
Beef in 10 per cent CO_2	-1-5	29	90-95	Up to 7 w
Veal	-1-0	30-32	90	1-3 w
Lamb	-1-0	30-32	85-90	1-2 w
Pork	-1.5-0	29-32	85-90	1-2 w
Bacon, green	-3 to -1	27-30	80-90	—
Bacon, smoked	-3 to -1	27-30	80-90	1 m
	4.5	40	—	Denmark
Lard, refined	-1-0	30-32	80-95	4-6 m
	-1-0	30-32	95-100	3-5 m
Edible offals	-1-0	30-32	75-80	3 d
(b) Poultry				
Chicken, eviscerated	0	32	85-90 or moisture-proof wrapping	7-10 d
Chicken, eviscerated covered by crushed ice		—	—	7-10 d
Fowl, uneviscerated	0-1	32-34	85-90 or moisture-proof wrapping	7-10 d (max. 3 w)
Fowl, eviscerated	0-1	32-34	85-90 or moisture-proof wrapping	7-10 d
(c) Rabbits	-1-0	30-32	90-95	Max. 5 d
(d) Eggs in shell (oiled or unoiled)	-1.5-0	29-32	85-90	6-7 m

Chilled Vegetables

Vegetables	Temp. °C	Temp. °F	R.H. per cent	Expected storage life
1	2	3	4	5
Artichoke	0	32	90-95	3-4 w
Artichoke (Jerusalem)	0	32	90-95	2-5 m
Asparagus	0-5	32-33	85-95	2-4 w

(Contd.)

1	2	3	4	5
Bean				
Runner bean	0--6	32-43	85-90	2-3 w
Broad bean	0	32	90-95	1-3 w
Bean (French green, snap)	2-7	36-45	85-90	10-15 d
Bean (fresh, shelled)	0-2	32-36	85-90	1 w
Beet (bunch)	0	32	90-95	10-14 d
Beet (topped)	0	32	90-95	1-3 m
Broccoli	0	32	90-95	10-21 d
Brussels sprout		30-32	90-95	3-6 w
Cabbage	0	32	85-90	2-4 m
Carrots, bunch	-1-0	32	90	1-2 w
Carrot, topped	-1-1	30-32	90-95	4-6 m
Cauliflower	0	32	85-90	2-3 w
Celery, leaf	0	32	90-95	1-2 m
Cucumber	11.5	53	85-95	1-2 w
Eggplant	7-10	45-50	85-90	10 d
Endive	0	32	90-95	2-3 w
Garlic	-2-0	29-32	70-75	6-8 m
Leek	0	32	90-95	1-3 w
Lettuce	0	32	90-95	1-3 w
Mushroom (cultivated)	0	32	85-90	5 d
Olive (fresh)	7-10	45-50	85-90	4-6 w
Onion	-3-0	27-32	70-75	6 m
Parsley	0-1	32-34	85-90	1-2 m
Parsnip	0	32	90-95	2-4 m
Pea (green)	-.5-0	31-32	85-90	2-4 m
Pimento	0	32	85-90	4-5 w
Potato, early*	3-4	37-39	85-90	A few wks
Potato late:				
(a) Ware	7-10	45-50	85-90	4-8 m
(b) Seed	3	37	85-90	5-8 m
Pumpkin	10-13	50-55	70-75	2-6 m
Radish	0	32	90-95	3-4 w
Radish (horse)	-1-1	30-32	90-95	10-12 m
Rhubarb	0	32	90	2-3 w
Salsify	0-1	32-34	90-95	2-4 m
Spinach, late	-.5-0	31-32	90-95	2-6 w
Summer squash	0-4.5	32-40	85-95	2-6 m
Sweet potato	13-16	55-60	80-85	4-6 m
Tapioca (tubers)	0-2	32-36	80-90	6 m
Turnip	0	32	90-95	4-5 m
Turnip-cabbage	0	32	90-95	2-4 w
Turnip-rooted celery	0-1	32-34	90-95	2-4 m
Watermelon	2-4.5	36-40	85-90	2-3 w

*If harvested in immature stage storage temperatures below 10°C (50°F) may cause severe chilling damages.

Frozen Fish

	Storage Temperature	
	-18°C (0°F)	*-25°C (-13°F)*
(a) Fat fish: herring, mackerel, sardines	2½-4 m	5-8 m
(b) White fish: cod, haddock, coal-fish	3-4 m	6-8 m
(c) Flat fish: flounder, plaice, sole	4-6 m	7-10 m
(d) Crustacea	About 4 m	About 8 m

Units of Refrigeration

There is no internationally agreed unit of performance, and any of the following may be encountered.

Ton Refrigeration: 322,000 Btu per 24 hr (Wymss Anderson), no operating conditions.

Ton Refrigeration: 318,080 Btu per 24 hr (Lloyds), –15°C (5°F) evap., 30°C (86°F) condenser.

Ton Refrigeration: 288,000 Btu per 24 hr (U.S.A.), –15°C (5°F) evap., 30°C (86°F) condenser.

(Note: The U.S.A. ton or short ton=2,000 lb)

Ton Ice Marking: 510,000 Btu per 24 hr (Wymss Anderson), no operating conditions.

International Unit: 342,860 Btu per 24 hr (Inst. Mech. Eng.), 0 to –5°C (32 to 23°F) evap., 15 to 20°C (59 to 68°F) condenser, –10°C (14°F) direct expansion.

Of these, the U.S.A. ton is the most commonly used.

Vibrating Conveyors

The movement of many materials is often best accomplished on long metal troughs which advance the materials by means of reciprocating or vibrating action. Features commending its use in food processing are: the ease by which the conveyor can be made totally enclosed and if necessary, made dustproof; no contact between moving parts and the load of materials; and process operations such as screening, cooling, heating and drying, etc., can be performed while the materials are being conveyed. Movement is secured either by application of the natural frequency principle of a spring supported mass or by electrical means.

Natural frequency mechanical vibrating conveyors consist basically of a trough mounted on a rigid base frame by means of

coil or leaf springs or a combination of both and connected through suitable linkage to a motor-driven eccentric shaft. The springs store energy on the downstroke, which is released to the conveyor trough in 'natural frequency' impulses requiring a minimum of external force on the upstroke. Each spring exerts an energy equal to its compressive force and becomes, in consequence, an individual drive unit. Combined, the springs supply about 75 per cent of the conveying energy needed and as a result only a low powered motor is needed to provide and maintain the frequency of the system.

Electric vibrating conveyors comprise one or more vibrating power units connected to a conveyor deck, which is thus subjected to vibration at the proper rate and at the correct angle to produce the desired results. The power unit is usually attached at an angle of 20°, so that as the deck moves forwards it also moves upwards at this angle and as it moves backwards it descends at the same angle. Movement on the deck is thus forwards and upwards. However, the material, being free to move, does not return with the backward movement of the deck, but falls under the slower force of gravity until it is intercepted by the next forward and upward stroke. The length of each vibrating stroke, and hence the rate of materials movement, is adjustable in a given machine from the maximum downwards. The stroke frequency is at all times constant since it is determined by the supply frequency, so the amplitude or stroke is adjusted by means of a variable resistance to give the desired speed of travel of any material over the deck.

Votator

See SCRAPED-SURFACE HEAT-EXCHANGERS.

Warehouses and Stores

Seeking the reduction in the number of handlings required constitutes a primary objective of layout of storage space; also by employing efficient handling methods, to secure a better utilization of storage space. The latter, in recent years, has led to increased resort to fork-lift truck, due to their ability to effect high tiering and make available the full cubic capacity of a store or warehouse. Although there is no uniform layout that can be applied to all warehouses and stores, for much will depend upon the class of materials that are to be stored, and their usage, or whether the

stores are to be constantly drawn upon and replaced, or if they are to be stored as a bulk shipment and withdrawn as such, the two accepted planned arrangements are known as '90 degree' and '45 degree' angle stacking. However, irrespective of the storage system adopted, storage area layout is considerably simplified by the use of a scale drawing of the area with cardboard scale models of pallets and fork trucks, for by employing standard size pallets a maximum utilization of available space is assured by correct planning revealing at the same time such desired information as to size of aisles required, etc.

The true value of 90° stacking is for solid packs when stowage and removal of goods is made in bulk, for even though more aisle space is needed than in angle or herringbone stacking, a smaller number of aisles are required; this type of pack is also adopted when the pack is solid against one or more walls of a building. However, when the removal of materials is required from four aisles, or materials are to be withdrawn at frequent intervals, then angle stacking at 45° offers many advantages as it will reduce the loss of space covered by the partial withdrawal of materials in storage, leaving spaces which cannot be filled until the pallets of the same lot of material are removed.

Height of stacking depends upon the strength of pack, capacity of handling equipment, warehouse floor load capacity and headroom. The term 'strength of pack' would mean in this case not only the strength of individual pallet loads, fragile commodities being suitably packed in boxes or box pallets or reinforced by wooden battens; but also that, in stacking boxes, crates, cartons and similar commodities, care should be taken to keep piles straight up and down. This distributes the load evenly over the top surface of the bottom loads in a tier and ensures greater stability than when goods are carelessly stacked.

While uniform 'ceiling stacking' in stores makes the fullest possible use of available floor area, instances do arise where the headroom in a storage exceeds the lift-height of a fork-truck, so in such instances additional storage can be secured, when building height and weight of unit-loads permit, by stowing two pallet loads together, thus for a 9-ft lift and the superimposing of, say, a 4-ft pallet load upon a load of similar height, stacking may be carried out up to a height of 17 ft, and with deeper loads to above this height.

Wheel Conveyors

Similar in principle to roller conveyors, when conveyors afford an economical means of handling material gravitationally. The wheels are attached to frames and are closely spaced to provide a smooth riding surface. Where conveyor lines are portable and must be moved often, as in loading and unloading road vehicles, wheel conveyors are well suited because of the lightness of their individual sections. One of the problems confronting the materials-handling engineers for some time was how to eliminate line pressure build-up during accumulation on a power conveyor, without stopping the entire line. This has been solved by the development of a range of automatic pressure conveyors. They include models of wheel-type and live-roller type conveyors, by means of which it is possible to convey most size and shapes of materials with ease and safety.

On the wheel-type conveyors, packages are moved along over the wheels by a 44-in wide centre belt. This centre belt imparts only enough friction on the bottom of the items to move them. All of the package weight is carried on the wheels. At various locations along the conveyor, pressure-sensing wheels are located. When these wheels are depressed by the leading container, the belt-supporting wheels under the following container will drop the driving belt from contact with the bottom of the package. This package will stop, but rest over other sensing wheels, which will cause belt pressure under the following packages to be released. As packages are released from accumulation, they move off smoothly and are automatically spaced out at regular intervals due to the fact that the second package will not move until the first is off the sensing wheels. The same will be true of the third and fourth items.

Wire Belt Conveyors

The belts used in conveyors of this type are generally constructed of bright mild steel wire when not exposed to moisture. Choice here is dictated by low cost and relatively high tensile strength in normal temperatures. The material does not begin to flex until temperatures above 350°C approx. (660°F) are encountered. For operation in moist atmospheres, it is usual to use galvanized wire, but while this offers a degree of protection against corrosion, the zinc coating provided by galvanizing is not

completely proof against oxidation. Where this is required, or more exactly, maximum resistance to corrosion caused by moisture and water, wire made of one of the anti-corrosion chrome steel alloys should be used.

Many forms of wire mesh belt are made to suit different applications. The simplest of all is fabricated by joining right- and left-hand woven wire panels by means of a crimped cross rod. Belts woven in one direction have a tendency to run towards one side of the terminal drums, so by alternating right- and left-hand panels a straight running belt is obtained. These belts are mainly suitable for handling light articles and a typical application is as an oven belt in the baking of biscuits. A similar weave having cross rods and fitted with side plates and side chains is frequently used in deep freeze tunnels in temperatures down to –40°C (–40°F). Handling operations in canneries and bakeries may often be satisfied by belts of the open mesh spiral type. These comprise alternating right- and left-hand spirals connected by crimped rods which ensure that the original shape of the belt is retained. The spirals cannot move when the belt is under tension and their disposition also ensures straight running. Furthermore, as each coil is independent of the next, the belts are very flexible, and there is little distortion in temperatures up to 600°C approx. (1,110°F).

In order to obtain very close mesh belts, it is possible to multiply the number of spirals and cross rods per pitch. The type of belt is frequently used in ovens, especially in baking ovens where the products are not handled in tins but directly on the belt. In some designs, ends of the cross rods are connected by means of S or U shape hooks so producing a strong, and at the same time, smooth edge. A further variant has insets in the spirals; it is used for the movement of soft materials which would penetrate and clog a normal close mesh belt, an example being in the automatic production of cakes.

Three other types finding wide application in food processing are the wire link, flat strip and woven spring steel. Wire link belts consist of single wire links connected by cross rods on which they are assembled. The edges of the belt are finished by a special washer, welded to each cross rod. Both drive and tail drums mounting the belt have grooves into which the cross rods and loops fit precisely. A positive drive is so produced, the whole belt acting as a chain. The assembly renders belt slip impossible and

the conveyor can easily be synchronized with other conveyors or machines.

Applications occur throughout canning and the general food industries, as in drying tunnels, freezing plants and sterilizing plant. The construction is particularly advantageous where through air circulation is required. Due to the strong welded edges it is possible to run the belt with only slight play on either side, a feature forcing the air to pass through the belt without short circuiting to the sides. Additionally, plate links may be fitted to the end rods, making it possible to support the belt on rollers. A smooth surface permits the use of scrapers and spring-loaded transfer plates and as the cross rod ends are no higher than the surface of the belt, sideways loading and off-loading can be effected.

The gaps between the links or loops can be varied considerably, thereby producing a smaller or larger open area. The latter is secured by inserting distance springs, wire rings or spacing collars between the wire links. These two factors are of importance in baking, drying and cooling operations. Increasing the open area gives increased air circulation and at the same time, because of the decreased weight of the belt, the heat load of the conveyor itself is reduced. As the belts consist of single wires and coils, clogging is almost impossible and cleaning can be easily done without removal of the belt from the conveyor.

Similar desirable characteristics are a feature of many flat strip belts. Made of bright mild, galvanized or stainless steel strip assembled on cross rods with either hooked or welded ends, these have good articulation, a large open area and are easily cleaned. Positive drive without slip is obtained by means of toothed sprockets, the number of which on the driving shaft is dependent on the length of the belt and the load on the conveyor. Used generally in bakeries and canneries, these conveyors can be used in sterilizing and pasteurizing plant, and freezing tunnels. Very low heat absorption is also a property of woven spring steel belt, made of either round or flat spring steel welded at the edges and supplied in almost any length in meshes from 1 1/2 mm, a wire thickness of 0.7 mm upwards and up to a width off approximately 80 in.

Woven spring steel belts are used mainly as an oven belt for

biscuits and other bakery products, carried directly on the belt. They are also of value in the drying and blanching of vegetables and fruit. As the mesh of the belt can be very fine, it is suitable for the immediate support of dough, without baking tins or trays, and it is claimed, the results obtained in many cases are better than with solid steel bands. Very little stretch is experienced in operation and the belts are simple to clean, whilst, due to the special method of weaving, belt tracking is good. However, as the weave does not consist of separate coils or links, as for spiral and wire link belts, it is necessary for the longitudinal wires to bend round the terminal drums or pulleys. This, in turn, necessitates a larger pulley diameter, a minimum of 800 times the thickness of the longitudinal wires. Support rollers along the conveyors can, of course, be of smaller diameter.

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M. Lalitha is a Nutrition and Health Foods Consultant to four well-known public hospitals in New Delhi, Haryana, Punjab and Uttar Pradesh. She is a graduate in Home Science from Lady Irwin College, New Delhi and also obtained her Master's degree in Food and Nutrition from the M.S. University, Baroda. She has been associated with the Mid-Day Meal for Schools panels of a number of States. Her well–known publications include two books–*Nutrition Fact and Fiction* and *Social Nutrition and Human Development*–and over two dozen acticles and papers in community health and nutrition issues.

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